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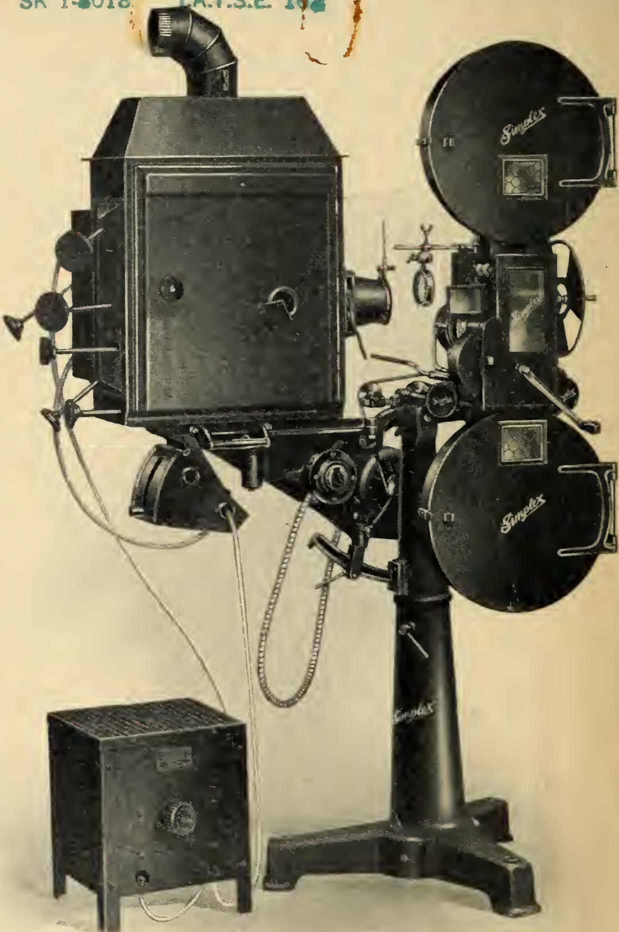

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MOTION PICTURE PROJECTION

An Elementary Text Book

BY

JAMES R. CAMERON

AUTHOR OF

MOTORS AND MOTOR GENERATORS
ELECTRICITY FOR OPERATORS
TEXT BOOK ON RADIO
RADIO FOR BEGINNERS
POCKET REFERENCE BOOK FOR
MANAGERS AND PROJECTIONISTS, ETC., ETC.

LATE TECHNICAL EDITOR

EXHIBITORS TRADE REVIEW
INTERNATIONAL CINEMA REVIEW
EDUCATIONAL FILM MAGAZINE

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New York City

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By JAMES R. CAMERON

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My Brother Members of the Society of Motion Picture Engineers and All Those Who in Any Way Assisted Me with This Work.

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Author's Foreword

In June, 1918, Motion Picture Projection made its first appearance. Its preparation was prompted by the need of a book on the subject of projection that was authentic, up to date and written so the amateur and student could readily understand it. The writer at this time held the office of director of projection with the American Red Cross and had charge of reconstruction work at the Institute in New York City. The book was immediately adopted by the American Red Cross, the Y. M. C. A., the Knights of Columbus and the Community Motion Picture Bureau as the official textbook on the subject, with a result that the first edition was quickly sold out.

There was a delay in getting the second edition to the printer, due to the fact that shortly after the signing of the armistice the writer was commissioned by the Exhibitors Trade Review to make a study of motion picture conditions in England, France, Belgium, Germany and Switzerland, and for something like seven months the writer spent his time in the aforementioned countries.

The second edition revised and enlarged was finally published in June, 1921, and met with instant favor in the industry.

The author of this book, though actively engaged in the Motion Picture business since 1902, does not wish to pose as an expert in all matters pertaining to projection. When one stops to con-

sider that to fill this role of expert one would have to be

(a) An expert electrician.
(b) An expert optician.
(c) An expert mechanic.
(d) An expert in photography,

besides having a good working knowledge of at least half a dozen other branches of sciences that are allied with the Motion Picture industry, one must admit it would be a hard role to fill. We know of several men who are rightly termed experts in their own particular branch of the industry, but we know of no one who can claim to be an expert in all its branches.

True, we know of at least one writer on the subject of projection who modestly admits he knows more about electrical appliances than the men who design and build them, more about the subject of optics than the men who made a life study of it, more about the Motion Picture machine than the builders of the projector themselves, and so on infinitum. For such a person we have only pity.

We have men in the industry who are daily applying themselves to their own particular branch, we have opticians who are doing nothing else but making a study of the optical system of the Motion Picture Projector, electrical engineers who are making an exclusive study of the merits of the various electrical appliances and devices used in Motion Picture work, mechanical engineers who are devoting their whole time to a study for the betterment of the Motion Picture Projector and accessories.

It is to these men that the author of this book turned for information and help. The Transactions of the Society of Motion Picture Engineers, a society formed for the advancement in the theory and practice of Motion Picture Engineering and the allied arts and sciences, have been freely quoted. The list of names on the acknowledgment page of this book is a representative one in the Motion Picture industry.

To the many thousands of readers of the earlier editions of this work—to the various Government Departments, Schools, Colleges and Libraries who adopted this book—to the Trade press and Lay press throughout the country who said such complimentary things about the book, my thanks are due and here extended, and I trust this, the third, edition of Motion Picture Projection will find favor in the industry.

JAMES R. CAMERON.

Publisher's Foreword

IN placing this, the third edition of Motion Picture Projection, on the market, we are of the belief that it will meet with the approval of all branches of the Motion Picture Industry and the vast and ever-growing army of readers of Cameron's textbooks.

In claiming that Motion Picture Projection is the standard authority on the subject, we are only echoing the expressions of the various U. S. Government Departments, Boards of Education, Universities and Colleges, etc., etc., who have adopted this work exclusively. This is the only book on projection that carries the endorsement of the I. A. T. S. E. and the M. P. M. O. of the U. S. and Canada. It is without doubt the largest, most comprehensive and authentic work on the subject of motion picture projection ever published.

TECHNICAL BOOK COMPANY.

Introduction

IN the Spring of the present year, the writer ventured to make a prophecy before the Society of Motion Picture Engineers about the motion picture theatre of the future. That prophecy spoke of a marked advance in projection during the next five years and improvement and progress in the machinery and equipment required for highly perfected projection of pictures.

It is because of the modern and improved equipment of to-day and the great things that will be developed along these lines in the future that the word motion picture "operator" is no longer applicable to the kind of work that is necessary and that we are now getting in motion picture projection. The word is "projectionist." The men who follow this calling in addition to being highly specialized and highly trained mechanics of the most expert kind, must in addition, be artists in their own particular line.

The equipment in use to-day—the automatic machinery, the high intensity arc, the advance in optics, the advance in light diffusion and screen surfaces—have placed on the projectionists the responsibility of executing what is one of the most important—if not the most important—function of the American motion picture theatre. Our large picture houses—where through various

stages of experimentation and concentrated study, we have succeeded in conquering traditional difficulties and establishing notable improvements in lamps, filters and shutters—require the services of men of imagination and artistry who are equally able to respond to the mechanical ond artistic phases of their work.

I do not think that my statement is far-fetched when I say that I expect some day to see my projectionists work in evening clothes, and the chief projectionist execute his duties in the capacity of an executive only. In that day they will deservedly be numbered among the best paid artists in the moving picture industry. It will require more than the average standard of mechanic, and in my opinion it will be a profession worthy of the serious consideration of the college man.

We are working slowly. We are dreaming wonderful things. We are visualizing marvellous projects. The work of the past is but the stepping stone to something much finer and better. To-day the motion pictures do not constitute an art; they are the result of the fusion of varied abilities. But wedded in the future to light, color, music and scents, they will come to be the highest expression of art that we shall know. I hope that I shall live to see that day.

(*Signed*) *S. L. ROTHAFEL.*

Capitol Theatre,
New York.
September 18, 1922.

GLOSSARY OF ELECTRICAL AND MECHANICAL TERMS

ACETATE. A salt formed by the action of acetic acid upon a base.

ACTUAL HORSE POWER. The exact useful power given out by an engine; found by subtracting the power used by the machine itself from the indicated horse power.

ACHROMATIC LENSES. The color effect caused by the chromatic aberration of a simple lens greatly impairs its usefulness. This may be overcome by combining into one lens a concave lens of flint glass and a convex lens of crown glass.

ALIGN. To place or form in line.

ALLOY. A mixture of two or more metals.

ALTERNATING CURRENT. A current that changes its flow of direction so many times a second according to the construction of the alternator. Written A. C.

AMMETER. An instrument used to measure the flow of amperes.

AMPERE. The unit of current strength.

AMPERE HOUR. The quantity of electricity passed by a current of one ampere in one hour.
One ampere flowing for one hour.
Two amperes flowing for one-half hour.
One-half ampere flowing for two hours: all equal one ampere hour.

ANCHOR BOLTS. Bolts used for fastening machines to their foundation.

ANTI-FRICTION METAL. A tin-lead alloy like Babbitt metal.

APERTURE. An opening of any description in a partition.

ARC. The arc between two carbon electrodes slightly separated.

ARC RECTIFIER. An apparatus used to change A. C. to D. C.

ARMATURE. A collection of pieces of iron designed to be acted on by a magnet.

ASBESTOS. A fibrous variety of ferro-magnesium silicate; is a non-conductor of heat and fireproof.

ASBESTOS COVERED WIRE. A cable containing very fine strands of copper wire all twisted together and covered with an asbestos covering. Used wherever heat is generated. On motion picture circuits used between the table switch and arc lamp.

AUTOMATIC. Self acting.

AUTOMATIC SHUTTER. The shutter covering the film aperture in gate of machine and controlled by the centrifugal or governor movement, is so arranged that the shutter will remain up so long as the machine is in motion, but should the machine stop for any reason then the shutter falls and cuts off the rays of light from the film in gate. (A fire prevention device.)

AUTO TRANSFORMER. A transformer provided with only one coil instead of two. Part of the coil being traversed by the primary circuit and part being traversed by the secondary circuit.

B. & S. W. G. Abbreviation for Brown & Sharpe Wire Gauge.

B. W. G. Abbreviation for Birmingham Wire Gauge.

B. X. Metal tubing containing two conductors, each conductor insulated from the other by a rubber covering, and both wires wrapped with a composition covering so as to completely fill the tubing.

BABBITT METAL. An anti-friction metal.

BACK FOCUS. Properly called working distance.

BACK FOCAL LENGTH OF LENS. The distance from the back of the lens to the film in the gate, while the film image is in focus on the screen.

BALANCE WHEEL. A fly wheel. A wheel added to machinery for the purpose of preventing too sudden variations in speed.

BALL & SOCKET JOINT. A joint in which a spherical object is placed within a socket made to fit it.

BALL BEARING. A bearing whose journal works upon a number of metal balls. Used to reduce friction to a minimum.

BED PIECE. The frame carrying the dynamo or motor.

BORE. The interior diameter of a cylinder.

BRUSH. A rod of carbon held in a holder and pressed against the commutator.

BUSINESS. Action by the player; e. g., business of shutting door.

BUST. A small, magnified part of a large scene.

CABLE. An insulated electric conductor.

CAM FRICTION. The friction existing between the cam and the member connected to it.

CAMERA. An expression used to command the photographer to begin taking the scene.

CANADA BALSAM. A gum obtained from the Balsam Fir of Canada. Used for cementing lenses.

CARBON. One of the elements, existing in three forms, charcoal, graphite and diamond. It is used as electric conductor for arc lamps and incandescent lamp filaments. The carbons used for arc lamps generally have a central core of soft carbon.

CARRYING CAPACITY. The capacity of an electrical conductor to carry current without overheating.

CENTIMETER. Unit of length, 0.3937 inch.

CENTRIFUGAL FORCE. The force which draws a body constrained to move in a circular path, away from the center of rotation.

CHANGE OVER. The stopping of one projecting machine and the simultaneous starting of a second machine in order to maintain an uninterrupted picture on the screen when showing a multiple-reel story.

CHECK NUT, generally called lock-nut. A nut placed over another nut on same bolt to lock the main nut in place.

CHROMATIC. Relating to color.

CHROMATIC ABERRATION. When white light is passed through a spherical lens, both refraction and dispersion (the decomposition of white light into several kinds of light) occur. This causes a separation of the white light into the various colors and causes images to have colored edges. This effect which is most observable in condenser lenses is due to the unequal refrangibility of the simple colors.

CINE. A prefix used in description of the motion-picture art or apparatus.

CIRCUIT. The path through which the electric current flows.

CIRCUIT BREAKER. Any apparatus for opening or closing a circuit.

CIRCUIT-CLOSED. A circuit closed so as to give the current a continuous path.

CIRCUIT, OPEN. A circuit with its continuity broken, as by the opening of a switch.

CLOSE-UP. Scene or action taken with the character close to the camera.

COLLODION. A solution of pyroxylin (soluble gun cotton) in ether. Used in film cement.

COMMUTATOR. That part of a dynamo that changes the direction of the currents.

COOLING PLATE. The plate around the film aperture on gate which protects the gate itself from getting overheated from the rays of light from arc lamp.

CONDUCTOR. Anything that will permit the passage of electricity. A wire.

CONDENSERS. A lens or set of lenses used to gather the rays of light from the arc lamp and bring them to a fixed point of focus on aperture in gate.

The lens combination which deflects the diverging rays of the luminant into the objective.

Collector Lens. The lens next to the source of light.

Converging Lens. The lens nearest the objective.

Middle Lens. Of a three-lens combination, the lens lying between the collector lens and the converging lens.

CONDUIT. A metal pipe through which electrical conductors are run.

CONTACT, ELECTRIC. A contact between two conductors giving a continuous path for the current.

CONSTANT LOAD. A load whose pressure is steady and invariable.

CONTINUOUS. Uninterrupted without break, or interruption.

CONVERTER. An electric machine or apparatus for changing the potential difference of an electrical circuit.

CORROSION. Chemical action which causes destruction of a metal, usually by oxidation or rusting.

CORRUGATED. Formed with a surface consisting of alternate valleys and ridges.

COULOMB. The practical unit of quantity of electricity. It is the quantity passed by a current of one ampere intensity in one second.

CRATER. The depression that forms in the positive carbon of a voltaic arc.

CURRENT FREQUENCY. The number of times alternating current changes its flow of direction a second. The changes are called cycles.

CUT-BACK. Scenes which are returns to previous action.

CUT-IN. Anything inserted in a scene which breaks its continuity.

CUTTING. Editing a picture by elimination of useless or unacceptable film.

DEVELOPING. Making visible the latent image in an exposed film.

DIRECT CURRENT. A current that flows in the one direction. Written D. C.

DIMMER. An adjustable choking coil used to regulate the intensity of electric incandescent lamps.

DIRECTOR. The person who directs the actual production of the photoplay.

DISSOLVE. The gradual transition of one scene into another.

DOUBLE EXPOSURE. The exposure of a negative film in a camera twice before development.

DOUBLE PRINTING. The exposure of a sensitive film under two negatives prior to development.

DOUSER. The manually operated door in the projecting machine which intercepts the light before it reaches the film.

DUPE. A negative made from a positive.

DUPLEX. Double; working in two ways at once.

DYNAMOS. A machine driven by power used to convert mechanical energy into electrical energy.

E. M. F. Abbreviation for electric-motive force.

ECONOMIZER. A step-down transformer.

EFFECTIVE APERTURE. The largest diameter of a lens available under the conditions considered.

ELECTRICITY. An unknown power; a powerful physical agent which manifests itself mainly by attraction and repulsions, also by luminous and heating effects, by violent commotions, by chemical decompositions and many other phenomena.

ELECTRODE. The terminal of an open electric circuit.

EQUIVALENT FOCUS. The distance from a point half way between the back and front combination of lenses to the film in the gate while picture is in focus on screen.

Can be obtained by measuring the distance between the front and back combination then dividing by two and adding the result to the back focal length. (Written E. F.)

The equivalent focus of a plurality of lenses in combination is the focal length of a simple thin lens which will under all conditions form an image having the same magnification as will the given lens combination.

EXHAUST FAN. An air propeller used to create a vacuum.

EXTERIOR. A scene supposed to be taken out of doors.

FADE-IN. The gradual appearance of the picture from darkness to full screen brilliancy.

FADE-OUT. The gradual disappearance of the screen-picture into blackness. (The reverse of fade-in.)

FEATURE. A pictured story, a plurality of reels in length.

FIRE TRAP. An arrangement of rollers on the upper and lower magazines through which the film is fed, used to prevent the flame, in case of fire, from entering the magazines.

FIXING. Making permanent the developed image in a film.

FLAT. A bit of painted canvas, or the like.

FLASH. A short scene, usually not more than three to five feet of film.

FLASH-BACK. A very short cut-back.

FOCAL. Pertaining or belonging to a focus.

FOCUS. The point of concentration. When rays reflected from all points meet or concur.

FOOTAGE. Film length measured in feet.

FLICKER SHUTTER. A revolving shutter on head of machine just in front of the projection lens, its use being to cut off the rays of light from screen while the film is in motion in gate.

FRAME (verb). To bring a frame into register with the aperture during the period of rest.

FRAME (noun). A single picture of the series on a motion-picture film.

FRAME LINE. The dividing line between two frames.

FRAMING DEVICE. An attachment on the machine which allows the operator to frame the picture on screen.

FUSE. A short length of wire of a given fusible point introduced into the electrical circuit.

FUSING POINT. The temperature at which metals melt and become liquid.

GENERATOR. An apparatus for maintaining an electrical current.

GOVERNOR MOVEMENT. The movement that works the automatic shutter, works by centrifugal force.

GRAPHITE. A soft form of carbon, used as a lubricant.

GROUND. The contact of an electrical conductor with the earth, or with some other conductor not in the circuit.

HORSE POWER. A unit of rate of work. Equal to the raising of 33,000 pounds, one foot in one minute; equal to 746 watts.

INDUCTION. The property of a charged body on A. C. to charge a neighboring body running parallel to it without any tangible form of connection.

INDUCTOR. A step-down transformer.

IMPEDANCE. Is to an A. C. circuit what resistance is to a D. C. circuit.

INSULATING TAPE. A prepared tape to cover the ends of bared wire.

INTERMITTENT MOVEMENT. The movement that drives the intermittent sprocket, generally a four-to-one movement.

INTERMITTENT SPROCKET. The sprocket which engages the film to give it intermittent movement at the picture aperture.

INSERT. Any photographic matter, without action, in the film.

INTERIOR. Any scene supposed to be taken inside a building.

IRIS. An adjustable lens diaphragm.

IRISING. Gradually narrowing the field of vision by a mechanical device on the camera.

JOINING. Splicing into a continuous strip (usually 1,000 feet) the separate scenes, titles, etc., of a picture.

KILOWATT. Equal to 1,000 watts.

LAMINATED. Made up of a number of thin sheets.

LANTERN PICTURE. A still picture projected on a screen by means of an optical lantern or stereopticon.

LANTERN SLIDE (see slide). The transparent picture from which a lantern picture is projected.

LEADERS. That piece of blank film attached to the beginning of the picture series.

LENS. A lens may be defined as a piece of glass or other transparent substance with one or both sides curved. Both sides may be curved, or one curved and other flat.

The object of the lens is to change the direction of rays of light and thus magnify objects or otherwise modify vision.

Lenses may be classed as:

Double convex	Double concave
Plano convex	Plano concave
Concavo convex	Convexo concave

The focus of a lens is the point where the refracted rays meet.

LIGHT BEAM. A bundle of light rays.

LIGHT RAY. A thin line of light.

LOCATION. Any place selected for the action of an outdoor scene.

LOST MOTION. Motion in a part of machine that produces no useful results.

LUBRICANT. An oil used to diminish friction in the working parts of machinery.

LUG. A wire terminal.

MAGAZINE VALVE. The film opening in the magazine of a motion-picture projector.

MAN POWER. Equal to one-tenth of a horse power.

MASKS. Opaque plates of various sizes and shapes used in the camera to protect parts of the negative from exposure.

MICA. A mineral more or less transparent and used for insulating.

MIL. Unit of length.

MIL, CIRCULAR. Unit of area.

MOTION-PICTURE. The synthesis of a series of related picture elements, usually of an object in motion.

MOTION-PICTURE FILM. The ribbon upon which the series of related picture elements is recorded.

MOTION-PICTURE PROJECTOR. An optical lantern equipped with mechanisms for suitably moving motion-picture film across the projected light.

MOTOR GENERATOR. A motor connected to a generator.

MOTOR REGULATOR. An adjustable rheostat used to regulate the speed of the motor.

MOVIES. Motion pictures.

MULTIPLE. Multiple connection is when each lamp draws its supply direct from the main and is not depending on any other lamp or set of lamps for supply.

MULTIPLE-REEL. A photoplay of more than a thousand feet of film in length.

NEGATIVE. The opposite to positive; the pole to which the current is supposed to flow.

NEGATIVE. The developed film, after being exposed in a camera.

NEGATIVE STOCK. Light, sensitive film intended for motion-picture camera use.

NON CONDUCTOR. Any material that does not conduct electricity.

OBJECTIVE. The picture-forming member (lens) of the optical system. The objective lens of a moving picture machine generally consists of four lenses, two in the front combination and two in the rear. The two lenses in the front are cemented together with Canada Balsam and called the compound lens. The back combination consists of two lenses separated by a metal ring, called the duplex lens.

The convex or greatest convex side of a lens always faces the screen.

OHM. The unit of electrical resistance.

OSCILLATION. A moving backward and forward; swinging like a pendulum.

OPTIENCE. A collection of persons assembled to see motion pictures.

PAM. Contraction for panorama.

PANORAM. The act of, or device for, turning a motion-picture camera horizontally, to photograph a moving object, or to embrace a wide angle of view.

PHOTOPLAY. A story in motion pictures.

POLARITY. Pertaining to the two opposite poles of a circuit; the positive and negative.

POLYPHASE. More than one phase, multiphase.

POSITIVE. The developed film, after being printed through a negative.

POSITIVE STOCK. The light-sensitive film intended to be printed upon through a negative.

PRE-RELEASE. A picture not yet released for public showing.

PRESSURE, ELECTRIC. Electric motive force, voltage.

PRIMARY COIL. The coil of a transformer, connected to the source of electrical supply.

PRIMARY COLORS. Red, yellow, blue.

PRIMARY POWERS. Water power, wind power, tide power, power of combustion, power of vital action.

PRINT. Same as "positive."

PRODUCER. The maker of photoplays.

PROGRAM. The complete show for a single optience.

PROJECTION DISTANCE. The distance between the screen and the objective of a stereopticon lantern or motion-picture projecting machine.

PROJECTION LENS. Properly called projection objective.

PROJECTION OBJECTIVE. The objective which forms an image of the lantern slide or film, upon the screen

PROPS. Contraction of properties. Objects used as accessories in a play.

RACING OF MOTORS. The rapid acceleration of speed of a motor when the load upon it is removed.

REEL. An arbitrary unit of linear measure for film—approximately a thousand feet.

REEL. The metal spool upon which the film is wound.

REFLECTION. The change of direction experienced by a ray of light when it strikes a surface and is thrown back or reflected. Light is reflected according to two laws.

(a) The angle of reflection is equal to the angle of incidence.

(b) The incident and the reflected rays are both in the same plane which is perpendicular to the reflecting surface.

REFRACTION. The change of direction which a ray of light undergoes upon entering obliquely a medium of different density from that through which it has been passing. In this case the following laws obtain:

(a) Light is refracted whenever it passes obliquely from one medium to another of different optical density.

(b) The index of refraction for a given substance is a constant quantity whatever be the angle of incidence.

(c) The refracted ray lies in the plane of the incident ray and the normal.

(d) Light rays are bent toward the normal when they enter a more refracted medium and from the normal when they enter a less refracted medium.

REGISTER. A term denoting facial expression of emotions.

RELEASE. The publication of a photoplay.

RETAKE. Rephotographing a scene.

REWIND. The process of reversing the winding of a film, usually so that the end to be first projected shall lie on the outside of the roll.

REWINDER. The mechanism by which rewinding is accomplished.

RESISTANCE BOX. A box filled with resistance coils connected in series.

RHEOSTAT. An instrument used to offer resistance to the flow of current. Made of a number of metal coils connected in series and mounted on a frame.

RUBBER COVERED WIRE. A cable either solid or stranded with a rubber covering and an outer protective covering of cotton braid. Used for mains for motion-picture work.

SCENE. The action taken at a single camera setting.

SCENARIO. A general description of the action of a proposed photoplay.

SCREEN. The surface upon which a picture is optically projected.

SECONDARY COIL. The coil of a transformer in which the current is induced, connected to the lamp.

SERIES. An electrical connection where lamps are connected so that they depend on each other for supply, the current passing through each lamp successively.

SHOOTING A SCENE. Photographing the scene.

SHORT CIRCUIT. Two wires of opposite polarity coming in contact with each other without any controlling device.

SHUTTER. The obscuring device, usually a revolving segmental disc, employed to intercept the light during the movement of the film in motion-picture apparatus.

Shutter—Working Blade (also variously known as the cutting blade, obscuring blade, main blade, master blade or travel blade). That segment which intercepts the light during the movement of the film at the picture aperture.

Shutter—Intercepting Blade (also known as the flicker blade). That segment which intercepts the light one or more times during the rest or projection period of the film to eliminate flicker.

SIXTY CYCLE A. C. This is when every part of the circuit is 60 times positive and 60 times negative every second. The current changes its flow of direction 60 times a second.

SINGLE PHASE. Using only two wires and one E. M. F. sometimes called monophase or uniphase.

SINGLE PICTURE CRANK (sometimes referred to as trick spindle). That spindle and crank on a motion-picture camera which makes one exposure at each complete revolution.

SLIDE (Stereo Slide). The transparent picture from which a screen still is projected.

SLIDING FRICTION. The friction existing between two bodies in sliding contact with each other.

SPEED REGULATOR. An attachment on machine (generally a friction disc arrangement) used to regulate the speed of machine (not the speed of motor).

SPHERICAL ABERRATION. The reflected rays of concave spherical mirrors do not meet exactly at the same point. This is called spherical aberration.

SPLICING. Joining the ends of film by cementing.

SPLIT REEL. A reel having two or more picture subjects thereon.

SPOT. The illuminated area on the aperture plate of a motion-picture projector.

SPROCKET. The revolvable toothed member which engages the perforations in the film.

STAGE CABLE. A cable containing twin conductors each insulated from the other and the whole thing covered with a composition covering. Used for temporary purposes.

STEP-DOWN TRANSFORMER. A transformer that steps down the voltage and raises the amperage.

STEP-UP TRANSFORMER. A transformer that steps up the voltage and lowers the amperage.

STEREOPTICON. A lantern for projecting transparent pictures, i. e., lantern slides, often a double lantern for dissolving.

STILL. A picture from a single negative.

STRIKING THE ARC. The act of bringing the carbons of an arc lamp together, and immediately separating them, thus establishing the arc.

SWITCH BOARD. A board to which wires are led connecting with cross bars or switches.

SWITCH, DOUBLE POLE. A heavy switch which connects and disconnects two leads simultaneously.

SWITCH, KNIFE. A switch with knife-like blades used on circuits carrying high amperage.

SWITCH, SNAP. A small switch made to give a sharp break used on home lighting circuits.

SWITCH, THREE WAY. A switch so constructed that by turning its handle, connection can be made from one lead to either of two other leads, and also so that connection can be completely cut off.

TAKE-UP (noun). The mechanism which receives and winds the film after it passes the picture aperture. Generally consists of a split pulley and tension spring, its use is to drive and control the speed and tension of the reel taking up the film in lower magazine.

TAKE-UP (verb). Winding up the film after it passes the picture aperture.

TENSION SPRINGS. On gate of machine, used to give the proper tension to film while passing aperture.

THREE WIRE SYSTEM. A system of distribution of electric current where three wires instead of two sets of two wires are used. The middle or neutral wire acts as positive wire for the negative, and as negative wire for the positive. The advantage of the system is the saving of copper.

THREE PHASE. A system of electrical distribution making use of three separate currents. These currents may be superimposed and generally only three wires are used in this transmission.

THROW. Projection distance. Distance from front combination of lens to screen.

TILT. The act of, or device for, moving a camera vertically while in use.

TINTING. Coloring a film by dyeing the gelatine side of it.

TONING. Coloring a film by chemical action on the silver image.

TRAILER. That piece of blank film attached to the end of a picture series.

TRANSFORMER. An apparatus used on alternating current systems to raise or lower the voltage.

TRANSVERTER. A motor generator set, an A. C. motor connected to a D. C. generator.

TRICK CRANK. A camera crank giving a single exposure for each turn.

TRICK-PICTURE. A picture in which unnatural action appears.

TWO PHASE. An A. C. system of electrical distribution making use of two currents of different phase. Can be arranged with either 3 or 4 wires.

VISION. A new subject introduced into the main picture, by the gradual fading-in and fading-out of the new subject, as, for example, to visualize a thought.

VOLTAGE. Electric motive force or pressure.

VOLTMETER. An instrument used to measure the electric pressure.

WATT. The practical unit of electrical power. Equal to amperes times volts.

WATT HOUR. Amount of watts times length of hours.

WORKING DISTANCE. The distance from the principal focus of a lens to its nearest face; e. g., the distance from the slide or film to the nearest lens of the objective.

MOTION PICTURE STANDARDS

The following have been adopted as standards by the Society of Motion-Picture Engineers, and are promulgated to encourage uniformity and standard practice throughout the Industry as a whole. Their early universal adoption will save the industry a great deal of present annoyance and monetary loss.

FILM SPEED. A film movement of sixty feet per minute through motion-picture mechanisms shall be considered as standard speed.

FRAME LINE. The dividing line between pictures on motion-picture film shall lie exactly midway between the marginal perforations.

INTERMITTENT GEAR RATIO. The movement of the intermittent gear shall be expressed in degrees of rotation during which the pin of the driver is in contact with the slot of the driven gear. For example, a gear in which the pin is engaged with the slot for one-quarter of a revolution of the driver shall be called a 90-degree movement; that in which the pin is engaged with the slot for one-sixth of a revolution shall be called a 60-degree movement, etc.

LANTERN SLIDE MAT OPENING. A standard opening in mats of lantern slides for use in conjunction with motion pictures shall be 3 inches wide by 2¼ inches high.

THUMB MARK. The thumb mark spot on a lantern slide shall be located in the lower left-hand corner next the reader when the slide is held so as to be read against a light.

LANTERN STRIP. A red binding strip to be used on the lower edge of the lantern slide.

PICTURE APERTURE. The standard film picture aperture in a projecting machine shall be 0.906 inch wide and 0.6795 inch high, namely, 29/32″ and 87/128″.

PROJECTION ANGLE. The maximum permissible angle in picture projection shall not exceed twelve degrees (12°) from a perpendicular to the screen surface.

PROJECTION LENS FOCI. The focus of motion-picture projection lenses shall increase in ¼″ steps to 8 inches and from 8 to 9 in ½-inch steps.

PROJECTION LENS MOUNTING. Picture projecting lenses shall be so mounted that the light from the film picture aperture shall have an uninterrupted full path to the rear component of the lens.

PROJECTING LENS HEIGHT. The standard height from the floor to the center of the projecting lens of a motion-picture machine shall be 48 inches.

PROJECTION LENS OPENING. The diameter of unit opening for projecting lens holder shall be 1 15/16 inch.

PROJECTION OBJECTIVES. Shall have the equivalent focal length marked thereon in inches and quarters and halves of an inch, in decimals, with a plus (+) or minus (—) tolerance not to exceed 1 per cent. of the designated equivalent focal length also marked by the proper sign following the figure.

REEL. The approved standard reel shall be 10 inches in diameter; 1½ inches inside width; with 5/16-inch center hole, with a key-way ⅛″ by ⅛″ extending all the way through; a 2-inch hub; and a permissible flange wabble of not more than 1/16-inch.

STANDARD PICTURE FILM. Shall be one and one-third inches wide, and carry a picture for each four perforations, the vertical position of the picture being longitudinal of the film.

STANDARD REEL FILM. Shall have black film leaders, with tinted (red, green or blue) trailers; should have marking thereon embossed rather than punched in the film; and each reel of a multiple-reel story should end with a title, and the next reel begin with the same title.

TAKE-UP PULL. The take-up pull on film shall not exceed 15 ounces at the periphery of a 10-inch reel or 16 ounces on a (11-inch) reel.

ELECTRICITY

No one knows exactly what electricity is, we do not even know what it consists of, we do know that electricity and magnetism are one and the same. Electricity is not matter nor yet is it energy, although it is a means of transmitting energy, and we know how to handle this force for this purpose.

It is an undeniable fact that energy cannot be created nor can it be destroyed, but we can convert one kind of energy into energy of another kind. For example, should we light a fire under a vessel containing water we will convert the heat energy from the coals to steam energy in the vessel containing the water, and we could again change this steam energy into mechanical energy, as is done with the locomotive.

It is also possible to convert mechanical energy into electrical energy, so by connecting the mechanical energy created by the steam to a dynamo we would produce electrical energy.

It is also possible to convert electrical energy into mechanical energy. A motor is used for this purpose.

The word dynamo is used to designate a machine which produces direct current as distinguished from the alternator or generator which produces alternating current. A dynamo does not create electricity but produces an induced electric-motive force which causes a current of electricity to flow through a circuit of conductors in much the same manner as a pump causes water

to flow through a pipe. The point to be settled in the minds of those taking up electricity is that the dynamo merely sets into motion something already existing, by generating sufficient pressure to overcome the resistance to its movement.

Although we speak of alternating and direct current, it should be clearly understood that it is impossible to get a continuous current with a dynamo. The current is really a pulsating one, but the pulsations are so small and follow each other so quickly that the current is practically continuous.

It is common knowledge that a battery supplies what is known as a current of electricity. To obtain the current there must be a complete, closed, conducting path from the battery through the apparatus which is to be acted on by the current, and back again to the battery.

For example, when connecting up an electric bell, a wire is carried from one binding post of the battery (Fig. 1) to one of the binding posts of the bell, and a second wire is brought from the other binding post of the bell back to the remaining binding post of the battery. Any break in the wire immediately causes the current to stop and the bell to be silent. This furnishes an easy method of controlling the ringing of the bell, since it is only necessary to break the circuit at one point to stop the current, or to connect across the gap with a piece of metal to start the current going again. Thus the battery supplies the power to operate the bell, and the button opens and closes the circuit and thus controls the delivery of that power to the bell. Similar considerations apply when using the city lighting circuit. Wires

from the generator at the central station are brought to the lamp, motor, or heating device to be supplied, and the flow of current to this device controlled by means of a switch. The switch consists of pieces of metal which may be brought into contact when desired. The operation of the switch makes or breaks the contact. One handle

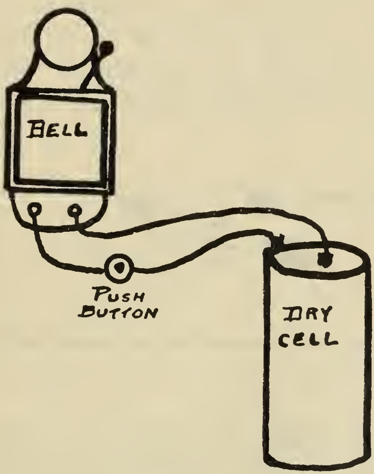


FIG. 1

may control two switches, so that with one motion the circuit can be broken at two places. The switch may be located on the wall and be of any one of a number of different forms, such as the "snap switch," the "push-button switch," and the "knife switch." The switch may be located in the socket which holds the lamp; such a socket is called a "key socket." It makes no difference at

which part of the circuit the current is interrupted. The flow of current will stop whether the break is made at the lamp, or in one wire at some distance from the lamp, or by opening a switch at the switchboard at the central station. Electricity must then be regarded as flowing in every part of the circuit, so that electricity is leaving the battery or dynamo at one side and going back to it at the other side.

Current.—The current flowing in a circuit is no stronger at one point of the circuit than at another. This can be proved by connecting a measuring instrument called an ammeter into

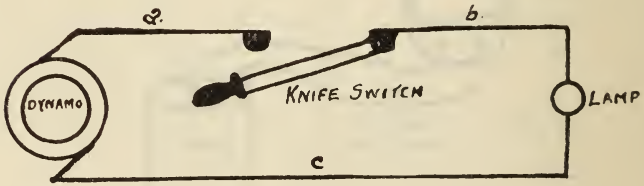


FIG. 2

the circuit at different points, *a*, *b*, or *c*, Fig. 2. It is found to register the same at whatever point this test is made. A useful illustration of the electric circuit is a closed circuit of pipe (Fig. 3) completely filled with water and provided with a pump, *P*, or some other device for causing the water to circulate. The amount of water which leaves a given point in each second is just the same as the amount which arrives in the same length of time. Now in the electric circuit we have no material fluid, but we suppose that there exists a substance, which we call electricity.

Electricity behaves in the electric circuit much like an incompressible fluid in a pipe line. We are very sure that electricity is not like any material substance which we know, but the common practice among students and shopmen of calling it "juice" shows that they think of it as like a fluid. We will, then, imagine the electric current to be a stream of electricity flowing around the circuit.

One way of measuring the rapidity with which water is flowing is to let it pass through a meter which registers the total number of quarts or gallons which pass through. By dividing the quantity by the time it has taken to pass we obtain the rapidity of flow. There are instruments by means of which it is possible to measure the total quantity of electricity which passes any point in the circuit during a certain time. If we divide this quantity by the time, we obtain the amount of electricity which has passed in one second. This is a measure of the current strength.

In practical work, however, the strength of the current is measured by instruments (ammeters) which show at each moment just how strong the current is, in somewhat the same manner as we may estimate the swiftness of a stream by watching a chip on the surface. This kind of an instrument enables us to tell at a glance what the current is without the necessity for a long experiment, and further we may detect changes in the strength of the current from moment to moment. In this connection it will be remembered that two measuring instruments are to be found on an automobile. The speedometer shows what the speed of the car is at each moment, so that the

driver may know instantly whether he is exceeding the speed limit, and govern himself as he sees fit. The other instrument shows how many miles have been covered on the trip, and of course the average speed may be calculated from its indications, if the length of the trip has been timed. The instrument of measuring total quantity of

Fig. 3

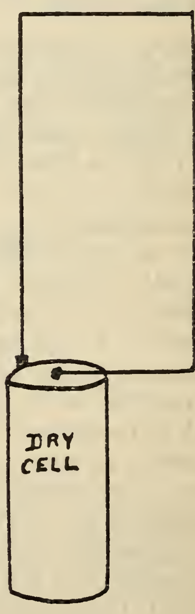


Fig. 4

electricity corresponds to the recorder of the total miles traversed; the ammeter corresponds to the speedometer.

Electromotive Force.—The water will not flow in the pine line, Fig. 3, unless there is some force

pushing it along—as, for example, a pump—and it can not be kept flowing without continuing the pressure. Electricity will not flow in a circuit unless there is a battery or other source of electricity in the circuit. The battery is for the purpose of providing an electric pressure. To this is given the name "electromotive force"—that is, a force which moves the electricity. This is usually abbreviated to "emf." The larger the number of cells which are joined in the circuit in such a way that their pressures will add, the greater the electric pressure in the circuit and the larger the current produced, just as the rapidity of flow of the water in the pipe line may be increased by increasing the pump pressure.

Resistance.—There is always some friction in pipe, whatever its size or material, and this hinders the flow of the water to some extent. If it were not for the friction, the water would increase indefinitely in speed. Similarly, there is friction in the electric circuit. This is called the "resistance" of the circuit. The greater the resistance the smaller the current which can be produced in the circuit by a given battery, just as the greater the friction the less rapid the flow of water with a given pump acting. A resistance coil at any point in the circuit corresponds to a partially closed valve in the pipe at any point (Fig. 5.).

Steady and Variable Currents.—If a pipe is connected to a large reservoir of water maintained at the same level, the steady pressure of the constant head of water will cause a steady flow of water in the pipe. The quantity of water which will pass a given point in one second will be the same at all times. Certain sources of elec-

tricity, such as batteries and some kinds of dynamos, produce an electromotive force which is practically constant, and will cause a practically constant current to flow in circuits to which they are connected. A steady electric current in one direction is called a "direct current."

In the case of the ordinary force pump, the water is given a succession of pushes all in the same direction but separated by intervals when the water is not being pushed. The heart is such a pump which applies successive impulses to the blood and causes it to circulate. A pipe supplied by a force pump is usually discharging some water all the time, but successive spurts occur when an unusually large stream of water is discharged for a moment, the frequency of these spurts corresponding to the rate at which the pump is being run. Similarly, there are sources of electromotive force which act intermittently. When such an electromotive force is connected to a circuit, the current flows always in the same direction but varies in magnitude from instant to instant. A current of this kind, which pulsates regularly in magnitude, is called a "pulsating current."

A very important kind of current for projection work is that known as "alternating current." This is analogous to the kind of flow which would be produced if, instead of being acted on by a pump, the water were agitated by a paddle which moved back and forth rapidly over a short distance, without traveling beyond certain limits. Under this impetus the water no sooner gets up speed in one direction than it is compelled to slow up and then gather speed in the opposite direction, and so on over and over again. The

water simply surges, first in one direction, and then in the other, so that a small object suspended in the water would not travel continuously around the pipe line, but would simply oscillate back and forth over a short distance.

The importance of the electric current lies in

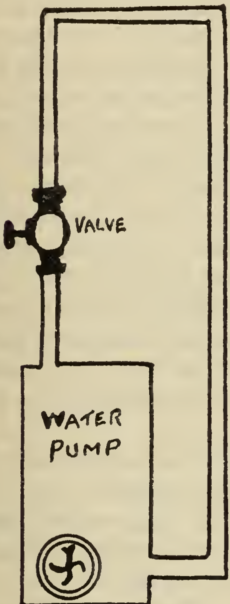


FIG. 5

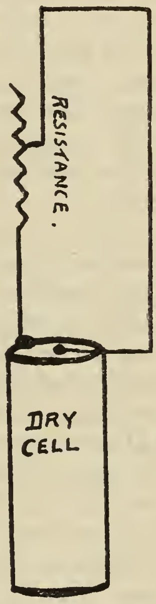


FIG. 6

the fact that it is an energy current. A current of water transports energy; so does a current of air. It is the motion that counts, and to utilize the energy of motion we must do something tend-

ing to stop the motion. In the case of water flowing in a channel we may do this by causing the water to flow under a water wheel whose resistance to turning causes it to absorb energy from the current of water.

Any material substance, by virtue of its mass, can be made to act as a vehicle for transporting energy from one place to another provided only it is set into motion. In the case of the electric current, we do not need to inquire whether electricity has mass. We are concerned, in the use of electrical apparatus, with the transformation of the energy of the current into other familiar forms of enegy—heat, light, and motion. The electric current is the vehicle by which we transmit energy from the central station to the consumer, and we are not, for practical purposes, concerned with the method of carrying the energy, any more than we need to inquire into the nature of the belt by which mechanical energy is carried from one wheel to another, or into the chemical nature of the water which is furnishing the power in a hydraulic plant.

The electric current itself can not be seen, felt, smelt, heard, or tasted. Its presence can be detected only by its effects—that is, by what happens when it gives up some of its energy. Thus, an electric current may give up some of its energy, and cause a motor to turn. Electrical energy has been given up, and mechanical energy takes its place. Similarly, electric energy may disappear and heat or light may appear in its place, or a chemical effect may arise. When a person feels an electric shock, it is not the current itself he feels, but the muscular contractions and other

physiological effects caused by the passage of the current. The electric lamp has an effect on the eye. We do not, however, see the electric current in the lamp, but the effect on the eye is due to the light waves sent off by the hot filament. The energy of the current has been changed over into heat in the lamp. When we hear a sound in the telephone receiver it is not the electric current we hear, but merely the vibration of the thin diaphragm. The electric current has used some of its energy in causing the diaphragm to vibrate. The acid taste noticed when the tongue is placed across the poles of a dry battery is due to the chemical decomposition of the saliva into other compounds as a result of the passage of the current through it.

Electromotive Force.—When a difference of electrical potential exists between two points, there is said to exist an *electromotive force,* or tendency to cause a current to flow from one point to the other. This electromotive force is analogous to the *pressure,* caused by a difference in level of two bodies of water connected by a pipe. The pressure tends to force the water through the pipe, and the electromotive force tends to cause an electric current to flow.

Electromotive force is commonly designated by the letters *E. M. F.* or simply *E.* It is also referred to as *pressure* or *voltage.*

Current.—A current of electricity flows when two points, at a difference of potential, are connected by a wire, or when the circuit is otherwise completed. Similarly, water flows from a high level to a lower one, when a path is provided. In either case the flow can take place only when the

path exists. Hence to produce a current it is necessary to have an electromotive force and a closed circuit. The current continues to flow only as long as the electromotive force and closed circuit exists.

The strength of a current in a conductor is defined as the quantity of electricity which passes any point in the circuit in a unit of time. Current is designated by the letter *C* or *I*.

Resistance.—Resistance is that property of matter, in virtue of which bodies oppose or resist the free flow of electricity. Water passes with difficulty through a small pipe of great length or through a pipe filled with stones or sand, but very readily through a large, clear pipe of short length. Likewise, a small wire of considerable length and made of poor conducting material offers great resistance to the passage of electricity, but a good conductor of short length and large cross-section offers very little resistance.

Resistance is designated by the letter *R*.

Volt, Ampere and Ohm.—The *volt* is the practical unit of electromotive force.

The *ampere* is the practical unit of current.

The *ohm* is the practical unit of electrical resistance. The *microhm* is one millionth of an ohm, and the *megohm* is one million ohms.

The International ohm, as nearly as known, is the resistance of a uniform column of mercury 106.3 centimeters in length by one square milimeter in cross-section at a temperature of zero centigrade.

The ampere is the strength of current which, when passed through a solution of silver nitrate,

under suitable conditions, deposits silver at the rate of .001118 gram per second.

The volt is equal to the E. M. F. which, when applied to a conductor having a resistance of one ohm, will produce in it a current of one ampere.

All substances resist the passage of electricity, but the resistance offered by some is very much greater than that offered by others. Metals have by far the least resistance, and of these, silver possesses the least of any. In other words, silver is the best conductor. If the temperature remains the same, the resistance of a conductor is not affected by the current passing through it. A current of ten, twenty or any number of amperes may pass through a circuit, but its resistance will be unchanged with constant temperature. Resistance is affected by the temperature and also by the degree of hardness. Annealing decreases the resistance of a metal.

Conductance is the inverse of resistance; that is, if a conductor has a resistance of R ohms, its conductance is equal to $\frac{1}{R}$.

Resistance Proportional to Length.—The resistance of a conductor is directly proportional to its length. Hence, if the length of a conductor is doubled, the resistance is doubled, or if the length is divided, say into three equal parts, then the resistance of each part is one-third the total resistance.

Resistance Inversely Proportional to Cross-Section.—The resistance of a conductor is inversely proportional to its cross-sectional area. Hence the greater the cross-section of a wire the

less is its resistance. Therefore, if two wires have the same length, but one has a cross-section three times that of the other, the resistance of the former is one-third that of the latter.

As the area of a circle is proportional to the square of its diameter, it follows that the resistances of round conductors are inversely proportional to the squares of their diameters.

Specific Resistance.—The specific resistance of a substance is the resistance of a portion of that substance of unit length and unit cross-section at a standard temperature. The units commonly used are the centimeter or the inch, and the temperature that of melting ice. The specific resistance may therefore be said to be the resistance (usually stated in microhms) of a centimeter cube or of an inch cube at the temperature of melting ice. If the specific resistances of two substances are known, then their related assistance is given by the ratio of the specific resistance.

Calculation of Resistance.—It is evident that resistance varies directly as the length, inversely as the cross-sectional area, and depends upon the specific resistance of the material.

If a circuit is made up of several different materials joined in series with each other, the resistance of the circuit is equal to the sum of the resistances of its several parts. In calculating the resistance of such a circuit, the resistance of each part should first be calculated, and the sum of these resistances will be the total resistance of the circuit.

Resistance Affected by Heating.—The resistance of metals depends upon the temperature, and the resistance is increased by heating. The

heating of some substances, among which is carbon, causes a decrease in their resistance. The resistance of the filament of an incandescent lamp when lighted is only about half as great as when cold. All *metals,* however, have their resistance increased by a rise in temperature. The percentage increase in resistance with rise of temperature varies with the different metals, and varies slightly for the same metal at different temperatures. The increase is practically uniform for most metals throughout a considerable range of temperature. The resistance of copper increases about .4 per cent. per degree Centigrade. The percentage increase in resistance for alloys is much less than for the simple metals. Standard resistance coils are therefore made of alloys, as it is desirable that their resistance should be as nearly constant as possible.

QUANTITY, ENERGY AND POWER

Quantity. The strength of a current is determined by the amount of electricity which passes any cross-section of the conductor in a second; that is, current strength expresses the *rate* at which electricity is conducted. The *quantity* of electricity conveyed evidently depends upon the current strength and the time the current continues.

The Coulomb. The coulomb is the unit of quantity and is equal to the amount of electricity which passes any cross-section of the conductor in one second when the current of strength is one ampere. If a current of one ampere flows for two seconds, the quantity of electricity delivered is two coulombs, and if two amperes flow for one second the quantity is also two coulombs. With a current of four amperes flowing for three seconds, the quantity delivered is 12 coulombs. The quantity of electricity in coulombs is therefore equal to the current strength in amperes multiplied by the time in seconds.

Energy. Whenever a current flows, a certain amount of energy is expended, and this may be transformed into heat, or mechanical work, or may produce chemical changes. The unit of mechanical energy is the amount of work performed in raising a mass of one pound through a distance of one foot, and is called the foot-pound. The work done in raising any mass through any height is found by multiplying the number of pounds in that mass by the number of feet through which

it is lifted. Electrical work may be determined in a corresponding manner by the amount of electricity transferred through a difference of potential.

The Joule. The joule is the unit of electrical energy, and is the work performed in transferring one coulomb through a difference of potential of one volt. That is, the unit of electrical energy is equal to the work performed in transferring a unit quantity of electricity through a unit difference of potential. It is evident that if 2 coulombs pass in a circuit and the difference of potential is one volt, the energy expended is 2 joules. Likewise, if 1 coulomb passes and the potential difference is 2 volts, then the energy expended is also 2 joules. Therefore, to find the number of joules expended in a circuit, multiply the quantity of electricity by the potential difference through which it is transferred.

Power. Power is the *rate* of doing work, and expresses the amount of work done in a certain time. The horse-power is the unit of mechanical energy, and is equal to 33,000 foot-pounds per minute, or 550 foot-pounds per second. A certain amount of work may be done in one hour or two hours, and in stating the work done to be so many foot-pounds or so many joules, the rate at which the work is done is not expressed. Power, on the other hand, includes the rate of working.

It is evident that if it is known that a certain amount of work is done in a certain time, the rate at which the work is done, or the power, may be obtained by dividing the work by the time, giving the work done per unit of time.

The Watt. The electrical unit of power is the watt, and is equal to one joule per second; that is, when one joule of work is expended in one second, the power is one watt. If the number of joules expended in a certain time is known, then the power in watts is obtained by dividing the number of joules by the time in seconds.

The power is obtained by multiplying the current by the voltage, or by multiplying the square of the current by the resistance.

The watt is sometimes called the *volt-ampere.*

For large units the *kilowatt* is used, and this is equal to 1000 watts. The common abbreviation for kilowatt is K. W. The *kilowatt-hour* is a unit of energy, and is the energy expended in one hour when the power is one kilowatt.

Equivalent of Electrical Energy in Mechanical Units. The common unit of mechanical energy is the foot-pound, and from experiment it has been found that one joule is equivalent to .7373 foot-pound; that is, the same amount of heat will be developed by one joule as by .7373 foot-pound of work.

As one horse-power is equal to 550 foot-pounds per second, it follows that this rate of working is equivalent to

$$\frac{550}{.7373} = 746 \text{ joules per second (approx.).}$$

Hence one horse-power is equivalent to 746 watts. Therefore, to find the equivalent of mechanical power in electrical power, multiply the horse-power by 746; and to find the equivalent of

electrical power in mechanical power, divide the number of watts by 746.

Ohms Law. Ohms law is merely the fundamental principle on which most of electrical mathematics are worked.

A series of formulas used by electricians in figuring voltage, amperage and resistance:

FORMULA 1

To find the amount of current flowing in a circuit divide the voltage by the resistance, or

$$\text{Current} = \frac{\text{Electric Motive Force}}{\text{Resistance}}$$

For instance, if we have a line voltage of 100 and our circut has a resistance of 5 ohms, then by dividing 100 by 5, we would get our amperage.

$$\begin{array}{l} 5\ )\ 100\ (\ 20 \\ \quad\ \ 100 \\ \quad\ \ \overline{} \end{array}$$

so we would have 20 amperes.

FORMULA 2

To find the amount of resistance in a circuit, divide the voltage by the amount of amperage drawn, or

$$\text{Resistance} = \frac{\text{Electric Motive Force}}{\text{Current}}$$

For instance, suppose we have a line voltage of 100 and are using 20 amperes at arc lamp, then by dividing the 100 by 20 we would get the amount of resistance we have in our circuit.

$$\begin{array}{l} 20\ )\ 100\ (\ 5 \\ \quad\ \ \ 100 \\ \quad\ \ \ \overline{} \end{array}$$

so we would have 5 ohms resistance in our circuit.

FORMULA 3

To find the voltage of a circuit, multiply the amount of amperes drawn by the amount of resistance, or

Electric Motive Force = Amperes times Resistance

For example: If we had 20 amperes at arc and our circuit was offering 5 ohms resistance, then by multiplying 20 by 5 we would get our voltage.

20 amperes
5 ohms

---

100 volts

To find Volts. Multiply number of Amperes by amount of Resistance.
To find Resistance. Divide Voltage by Amperage.
To find Amperage. Divide Voltage by Resistance
To find Watts. Multiply Voltage by Amperage.
To find Amps. Divide Watts by Volts.
To find Volts. Divide Watts by Amperage.

GENERATION OF ELECTRICITY

Everyone is acquainted with the horseshoe magnet and the small pocket compass, and these two articles will serve as an illustration.

Now if one of the legs of the horseshoe magnet be brought near the compass, it will be found that one end of the needle will be attracted to it, whilst if the other leg be presented the other end of the needle is attracted. One leg, at its end, has north polarity, because it attracts the south pole of the compass needle, whilst the other end, having south polarity, attracts the north end of the needle, so that between the ends of the two legs there exists what is known as a "magnetic field," or space wherein magnetic lines of force are present. These lines of force are invisible, but if the magnet be laid on a table, and a piece of paper put over it, and if on the paper be sprinkled some iron filings it will be found, when the paper is tapped by the finger, that these filings group themselves around the ends of the magnet in circles, being closer together at the ends than further away, or higher up towards the bend of the horseshoe. The magnetic field is the most dense between the legs of the magnet at their ends. If a copper wire be passed up and down between the ends of the legs an electric current will be induced in the wire, its direction of flow varying with the upward and downward motion of the wire. In this case the electricity is obtained from the magnet by "induction," this being the elementary principle upon which all dynamos, whether for lighting

or power, are based. In the dynamo the horseshoe is replaced by electro-magnets, the large stationary pieces of soft iron surrounded with covered copper wire, whilst the armature, the part which revolves, replaces the thin pieces of copper wire in the above simple experiment. The armature does not touch the magnets, and there is no friction except that in the bearings of the armature shaft, in which it is necessary to revolve, and which is made as easy as possible by a liberal supply of oil. It will also be seen that the electricity is not pumped from the atmosphere, but is simply the revolution of a bundle of copper wires between the poles of a powerful electro-magnet. The ends of the electro-magnets are thickened out, and each one made semi-circular so that the armature may revolve between the north and south poles and the electro-magnets, consisting of soft iron, are wound round with insulated copper wire, so that a portion of the electricity generated in the armature may be shunted around them and so keep always, whilst the dynamo is in action, as powerful electro-magnets. When the dynamo is stopped, these magnets retain a small amount of magnetism, which is gradually strengthened to its maximum as the armature is started revolving, the dynamo "building up" as it is termed. Anyone who has watched the starting up of a dynamo will have noticed that when running slowly the lamp connected to it as "pilot" gradually shows a red filament, which becomes brighter as the revolutions increase, until, when the correct speed is reached for which the dynamo was designed, the right voltage will show on the

voltmeter and the pilot amp attain its full brilliancy.

The armature of the dynamo is the only part which revolves, and this consists of a steel shaft supported in bearings at each end, to which the pulley is attached to receive the belt for transmitting the power from the engine to the dynamo. On the shaft are built up thin sheets of soft iron provided with grooves in which the different sections of insulated copper wire are laid lengthwise, their ends being connected to what is called the "commutator" fastened to the shaft. This consists of bars of copper made into a drum, each bar being insulated from its neighbor by means of strips of mica, and on the commutator rest lightly the carbon or copper brushes to convey the electricity to the lamps or motors.

The number of coils of wire on the armature depends upon the voltage the dynamo is designed to give, and the speed at which it has to run, also upon the strength of the magnetic field of the electro-magnets; and the thickness of these conductors will depend upon whether it has to give a large or small current strength. If the voltage is to be high, and small current strength, many conductors of fine wire are employed; if the voltage required is to be low, and large current strength, a few sections of thick wire are required.

A machine as above described is known as a continuous-current dynamo, to distinguish it from an "alternator," and the current obtained from it flows in a continuous circuit from the positive brush or collector on the commutator, through the lamps or motors, and completes the circuit to the other brush.

The mistaken notion of electricity being obtained by friction has probably arisen from the fact that, resting on the top and bottom of the commutator are carbon or copper brushes, but these are for the purpose of turning the currents, which are generated in the armature as alternating currents, into one direction. They also act as collectors to convey the electricity to the external circuits or lamps, motors, or other electricity-consuming devices, and do not offer practically any friction, only resting lightly against the surface of the revolving commutator.

For supplying extensive areas such as towns where the demand for electricity is scattered, alternating-current machines or "alternators" are employed which do not require commutators, the high voltage generated, 2000 volts and upwards, being led to transformer stations, where it is reduced by means of stationary transformers, to 110 and 220 volts for feeding lamps direct, or for motors and other uses. The field magnets of these alternators are energised by a continuous or direct current supplied from a small dynamo generally fixed on the alternator shaft, and running at the same speed.

ALTERNATING CURRENTS

A continuous or direct current is one of uniform strength always flowing in one direction, while an *alternating current* is continually changing both its strength and direction. The various principles and facts concerning direct current distribution apply also to alternating current systems. But in addition to the simple phenomena due to the resistance, which occur with direct currents, there are certain additional factors that must be considered in connection with alternating current transmission.

The flow of a direct current is entirely determined by the ohmic resistance of the various parts of the circuit. The flow of an alternating current depends upon not only the resistance, but also upon any *inductance* (self or mutual) or *capacity* that may be contained in or connected with the circuit. These two factors, inductance and capacity, have no effect upon a direct current after a steady flow has been established, which usually requires only a fraction of a second. In an alternating current circuit either or both of them may be far more important than the resistance and in some cases may entirely control the action of the current. Alternating current problems involving the consideration of three factors are usually more complicated and difficult to solve than those relating to direct currents. By an extension of the principles and methods employed for direct currents, however, alternating current systems can be designed correctly and without great difficulty.

The only reason practically for employing alternating currents for electric lighting and power purposes is the economy effected in the cost of transmission, which is accomplished by the use of high voltages and transformers. The cross section of a wire to convey a given amount of electrical energy in watts with a certain "drop" or loss of potential in volts, is inversely proportional to the square of the voltage supplied; that is, it requires a wire of only one-quarter the cross-

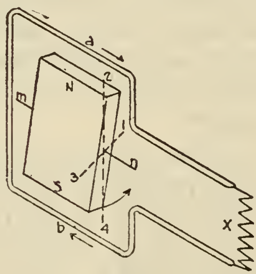


Fig. 7

section and weight if the initial voltage is doubled. The great advantage thus obtained by the use of high voltages can be realized either by a saving in the weight of wire required or by transmitting the energy to a greater distance with the same weight of copper.

When the alternating current, or E. M. F., has passed from zero, to its maximum value, to zero, in one direction, then from zero, to its maximum value, to zero, in the other direction, the complete set of values passed through repeatedly during that time is called a *cycle*. This cycle of changes constitutes a complete *period*, and since it is repeated indefinitely at each revolution of the

armature the currents produced by such an E. M. F. are called *periodic currents*. The number of complete periods in one second is called the *frequency* of the pressure or current.

The term *frequency* is applied to the number of cycles completed in a unit of time—one second. The word *alternations* is sometimes used to express the frequency of an alternator, meaning the number of *alternations per minute*. In practice the frequency is usually expressed in *cycles*. An alternation is half a period or cycle; since the current changes its direction at each half cycle, it follows that the number of alternations or reverses is twice the number of cycles.

If the current from an alternator performed the cycle sixty times a second, it would be said to have a *frequency* of 60 *cycles*, which would mean 120 alterations per second, or 120×60 seconds $=$ 7200 alternations per minute.

The frequency of an alternating current is always that of the E. M. F. producing it.

Unless otherwise specified, *frequencies* are in the term of cycles, thus: a frequency of 60 means 60 cycles. The frequency of commercial alternating current depends upon the work it is expected to do. For power a low frequency is desirable, frequencies for this purpose varying from 60 down to 25.

For lighting work frequencies from 60 to 125 are in general use. Very low frequencies cannot be used for lighting owing to the flickering of the lamps. A number of central stations have adopted a frequency of 60 as a standard for lighting and power transmission.

Most of the peculiarities that alternating current exhibits, as compared with direct current, are due more or less to the fact that an alternating current is constantly changing, whereas a con-

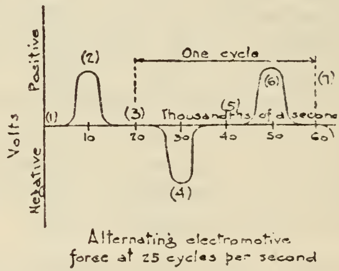


FIG. 8

tinuous current flows uniformly in one direction. When a current flows through a wire it sets up a magnetic field around the wire, and since the current changes continually this magnetic field will also change. Whenever the magnetic field surrounding a wire is made to change, an E. M. F. is set up in the wire, and this induced E. M. F. opposes the current. For example, when the current rises in the positive direction, the magnetism increases, in let us say, the clockwise direction about the conductor; after the current passes the maximum value and begins to decrease, the lines of force commence to collapse, reaching zero value when the current reaches zero; then when the current rises in the negative direction the magnetic lines expand in the counter-clockwise direction, and so on. The result is that the counter

E. M. F. of self-induction, instead of being momentary, as when the current is made and broken through a conductor, is continuous, but varies in value like the applied E. M. F. and the current. The value of an induced E. M. F. is proportional to the rapidity with which lines of force are cut by the conductor, and as the lines of force vary most rapidly when passing the zero point (changing from + to —) or *vice versa,* the induced E. M. F. is maximum at that moment.

When the current, and therefore the magnetism, is at the maximum value in either direction, its strength varies very little within a given momentary period of time, and consequently the *induced* E. M. F. is zero at the moment the current and magnetism are at maximum, the E. M. F. of self-induction not rising and falling in unison with the applied E. M. F. and the current, but lagging behind the current exactly a quarter of a cycle.

This property of a wire or coil to act upon itself *inductively* (self-induction) or of one circuit to act inductively on another independent circuit (mutual induction) is termed *Inductance.*

The *Unit* or *Coefficient* of inductance is called the *henry,* the symbol for which is L.

Many devices met with in alternating current work have this property of inductance. A long transmission lines has a certain amount of it, as have induction motors and transformers.

The effect of *inductance* in an alternating current circuit is to oppose the flow of current on account of the counter E. M. F. which is set up. This opposition may be considered as an apparent

additional resistance and is called *reactance* to distinguish it from ohmic resistance.

Reactance is expressed in ohms, like resistance, because it constitutes an opposition to the flow of the current. Unlike resistance, however, this opposition does not entail any loss of energy because it is due to a counter pressure and is not a property analogous to friction. Its effect in practice is to make it necessary to apply a higher E. M. F. to a circuit in order to pass a given current through it than would be required if only the resistance of the circuit opposed the current.

PRODUCTION OF E. M. F. BY REVOLVING FIELD

The motion of a conductor across a magnetic field causes an electromotive force in the conductor. This is true whether it is the conductor or the magnetic field that actually moves; the essential thing is that there shall be relative motion of one with respect to the other.

One way in which such relative motion may be secured is illustrated by Fig. 7. Suppose the magnet *NS* is made to rotate continuously in a vertical plane about the axis *mn*. The loop of the wire *ab* is stationary. Its ends are connected to some external part of the circuit *X*. As the field from the *N* pole sweeps across *a*, an electromotive force is induced in it to the right and at the same time an electromotive force is induced to the left in *b* by the passing of the *S* pole. Thus the E. M. F. produced tends to send a current in a clockwise direction around the loop *ab*, as indicated by the arrows.

When the magnet has made half a revolution the poles have exchanged places with respect to *a* and *b* and the electromotive forces are counterclockwise around *ab*. As the magnet continues to be rotated, there are thus two pulses of electromotive force (and of current if the circuit is closed) in opposite directions for each revolution of the magnet. The device described constitutes a simple "alternating-current generator" or "alternator."

The direction of the electromotive force induced in a straight conductor moving across a magnetic field can be determined by the "right-hand rule." This rule as generally stated assumes that the magnetic field is stationary and that the conductor moves across the magnetic field. Using the *right* hand, the thumb, the first finger, and the second finger are so placed that each is at right angles with the other two, the first finger being extended directly out. Then if the thumb is pointing in

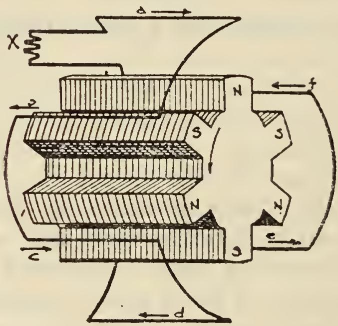


FIG. 9

the direction of motion, and the first finger is pointing in the direction of the magnetic lines of force (from north pole to south pole), then the second finger will point in the direction of the induced E. M. F.; that is, in the direction in which the induced current will flow.

If the magnetic field is moving, and the conductor stationary, the rule is readily applied by recalling that the relative motion is the essential thing. Thus in Fig. 7 the effect of havin the north pole move toward the reader, passi the

conductor a, is the same as if the conductor were to move away from the reader, passing pole N.

A similar *left*-hand rule can be used for determining the direction in which a straight conductor carrying a current will move if placed across a magnetic field. Using the *left* hand, the thumb, the first finger, and the second finger are so placed that each is at right angles to the other two, the first finger being extended directly out. Then if the first finger is pointing in the direction of the magnetic lines of force and the second finger is pointing in the direction in which the current is flowing, the thumb will point in the direction in which the conductor will move.

If the electromotive force is called positive when to the right in a, and negative when to the left, the changes in it may be shown by a curve like Fig. 8. Successive moments of time are taken along the horizontal axis, and the corresponding electromotive forces are shown by the height of the vertical ordinates. When the north pole is in position 1, Fig. 8, no emf. is induced. This is shown by the point marked 1, Fig. 8. A short time afterward, in position 2, Fig. 8, a certain maximum emf. is induced, shown by point 2 on the curve. When the pole has moved to position 3 the electromotive force has decreased to zero, and in position 4 it has reached a negative maximum. It then decreases again to zero and the whole series is repeated.

A curve like the one in Fig. 8 is called an electromotive force curve or wave.

The emf. curve generated by commercial alternators have a variety of shapes, but ordinarily they are not very different from sine curves.

A regularly recurring series of values of electromotive force, from any point in the series to the corresponding point in the next series, is called a "cycle." The portion of the curve in Fig. 8 from 3 to 7 represents a cycle; similarly, the portion from 2 to 6. The time required for one cycle is the "period." The number of cycles per second is called the "frequency."

In commercial practice, 60 and 25 cycles per second are the most common frequencies for alternating current circuits. The corresponding periods are 1/60 and 1/25 of a second.

To produce a frequency of 60 cycles per second by the use of a single magnet with two poles requires a speed of rotation of 60 revolutions per second. Such a speed is not practicable for large machines. To get 500 cycles would require 500 r. p. s., or 30,000 r. p. m. (revolutions per minute). By arranging a number of similar north and south poles alternately, as in Fig. 9, and providing corresponding conductors, a lower speed of rotation may be used. As in Fig. 9, the magnet is supposed to be made to rotate, while the conductors *a, b, c, d, e, f* remain stationary.

When the upper north pole is coming toward the reader, electromotive forces will be induced in the several conductors in the direction of the arrows. The conductors are all connected in series, except between *f* and *a*, where connection is made to an external part of the circuit, *X*. All are in the same relative position to the several magnetic poles, their electromotive forces are equal, and in the case shown, the total is six times as great as the electromotive force in any one conductor.

For every revolution of the magnet, each conductor is passed three times by an *N* and three times by an *S* pole. Each pair of poles gives rise to a cycle, so for each revolution there are three cycles of emf. in the conductors. Thus, for a given speed, the frequency is three times as high as it would be if there were but one pair of poles.

The magnets (*NS*, in Fig. 10) which produce the magnetic field of an alternator are called the "field magnets." If there is but one north and one south pole, the machine is said to be "bipolar"; if there are several pairs of poles the machine is "multipolar."

The conductors in which the electromotive forces are induced constitute the "armature winding." The winding is supported, usually by being embedded in slots, well insulated, on an iron or steel core, called the "armature core." Winding and core together constitute the "armature," though this term is also used, loosely, when the armature winding alone is meant.

The electromotive force developed in one conductor of an ordinary generator is only a volt or two, not enough for practical use. Armature windings, therefore consist of a large number of conductors, usually combined into coils of several turns each, which are pushed into slots in the face of the armature core and then connected by soldering. The joints have to be carefully covered with tape or other insulating material.

The coils are made of copper wire covered with insulation (usually cotton) wound to the proper shape on a form, wrapped with tape, and finally covered or impregnated with an insulating compound. The core slots are often lined with tough,

heavy paper or fiber. After being placed on the core, the coils are held by wedges of fiber or wood driven into the tops of the slots.

The core is built up of thin, flat sheets of soft iron or steel, ring-shaped, with teeth on the inner edge. Enough sheets are stacked up to make a cylinder of the length desired. Occasionally a separator is included to provide air ducts through the core for ventilation. The teeth are carefully lined up, and the spaces between them become the troughs or slots for the windings.

How the emf. increases and decreases in such a winding, can be studied from Fig. 11. Here the

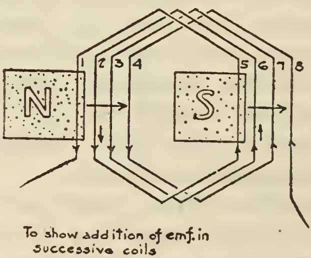


Fig. 10

coils are drawn as if the armature were unrolled and opened out flat. The magnet poles are supposed at the given instant to be over the rectangles marked *N* and *S*. Each of the numbered lines in the figure may represent either a single conductor or one side of a coil. Only a portion of the armature winding is represented.

Imagine the poles in Fig. 99 to be moving toward the right, the conductors 1, 2, 3, etc., remaining stationary. Starting at the instant when

a north pole is just approaching conductor 1, and a south pole conductor 5, electromotive forces will be induced in the directions shown by the arrows. As conductors 2 and 6, 3 and 7, etc., are reached, additional electromotive forces are induced. The maximum comes when the *N* pole covers 1, 2, 3, and 4, and the *S* pole covers 5, 6, 7, and 8. After that the resultant electromotive force begins to decrease, falling to zero and then beginning to increase in the opposite direction. In this manner an alternating emf. is gotten in which the changes

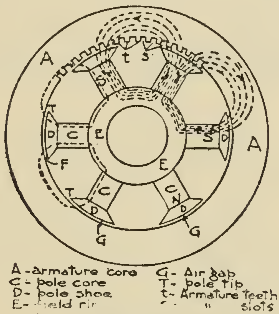


FIG. 11

occur gradually as conductors get into or out of the magnetic field one by one, or at least coil by coil. In addition the edges of the poles are usually tapered off ("chamfered") to make the changes still smoother.

Sometimes all the turns for one pair of poles are combined into one coil, which is put into a single pair of large slots, one for each pole. Such a winding is a "concentrated" winding. When the portion of the core under each pole face contains a number of slots in which the coils are placed, the winding is "distributed."

It is important to get an understanding of the magnetic path in an electric machine. Various shapes are possible, but an understanding of one makes all others easy. Fig. 11 is a diagram indicating the parts of a typical magnetic circuit, with their names. It is not intended to show details of mechanical construction. The fine lines in the upper part of the figure show the path of the magnetic flux for one pair of poles. The paths for the other poles are similar. The armature conductors are placed in the slots, *ss*.

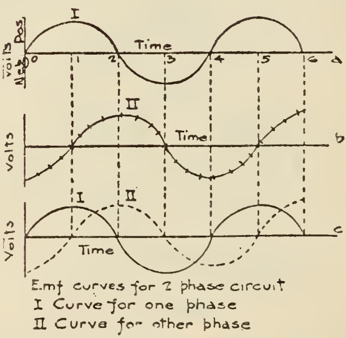


FIG. 12

Thus far nothing has been said as to how the magnetic field is produced. While permanent magnets might be used, they are not satisfactory for practical purposes, except in the very little machines called "magnetos." Electromagnets are therefore used. The poles are fitted with coils or spools of wire, usually of a large number of turns, through which direct current is sent from some external source.

The coils are connected to a pair of metallic rings, called "slip-rings" or collector rings, which

are in contact with conducting strips, called "brushes," connected to the source of current. As the entire field structure rotates, current is brought to the coils through the sliding contacts of the stationary brushes with the revolving slip-rings.

The source of direct current is usually a separate small direct-current generator, which when used for this purpose is called an "exciter." If used for one alternator alone its output will range from 1 to 3 per cent of the rating of the alternator.

When it is desired to refer to the stationary and rotating members of a dynamo-electric machine

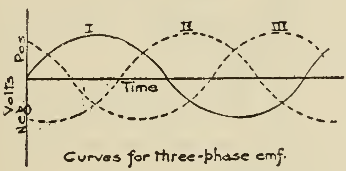


FIG. 13

without regard to their functions the former is called the "stator" and the latter the "rotor."

Definitions.—A machine for a simple alternating current is called a "single-phase" machine.

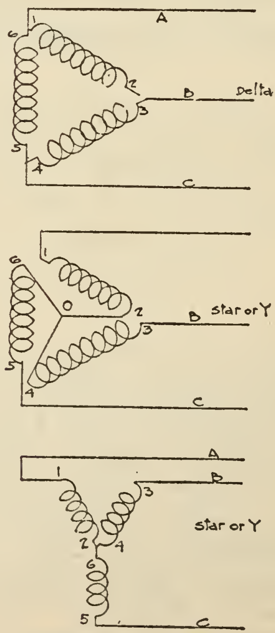
A machine for alternating current of two or more phases is called a "polyphase" machine; polyphase generators are either two-phase or three-phase, almost without exception.

Arrangement of Windings.—An idea of the way the windings of a polyphase generator are arranged may be obtained by referring back to

Fig. 11. Suppose another winding to be added identical with the one shown, but occupying the spaces left vacant by the first winding. As the magnet poles move along the windings come into play alternately.

Notice that in a single-phase generator half the surface of the armature core has to be left vacant. In a polyphase generator, on the contrary, the windings may cover the entire surface, and usually do.

Next, suppose the two-phase windings were



Three phase connections

FIG. 14

each made narrower, leaving space for a third winding just as large as each of the first two. We should then have three phase windings, and a given field pole would pass them one after the other. Thus would be produced three emfs. differing in phase by equal amounts.

By properly selecting the terminals, the three emfs. would follow one another as represented in Fig. 11, and it will be seen that now the difference between them is one-third of a cycle. In the time of one cycle each of the three comes to a positive peak one after the other. The emf. curves are shown in Fig. 12. The emfs. are often spoken of as differing by 120°.

It might be expected that a three-phase machine would have six terminals. As a matter of fact, the phases are usually so connected in the machine that three terminals are sufficient, as illustrated in Fig. 14. The three coils stand for the three armature windings. When joined as in the upper sketch, they are said to be connected in "delta"; when one end of each coil is brought to a common junction as at *O* in the middle figure they are connected in "Y" or "star." The lower figure is the same as the middle one, in that terminals 2, 4, 6 are all joined together and 1, 3, 5 are connected to the line wires *A. B. C.* By changing the position on the paper the connections are made to look simpler.

The scheme of connections is ordinarily of no interest to the operator, except in case of trouble, and cannot be determined without a close examination. The wires by which the connections are made are carefully wrapped and tucked away at the end of the armature, concealed by an over-

hanging part of the frame or by the end shield, which has to be taken off before the connections can be traced.

Of the mechanical energy supplied to a generator by its prime mover, not all appears in electrical form in the circuit. Some is unavoidably transformed into heat, and thus lost for practical purposes. The losses, which may be called power losses or energy losses, may be classified as—

1. Mechanical losses.
2. Copper losses.
3. Core losses.

Mechanical losses are those due to friction in the bearings, friction at the brush contacts, and friction between the air and the moving part of the machine, commonly called windage. The latter is not important in low-speed machines, but becomes prominent in the case of very high-speed generators. Generators of the kind we are discussing are driven at nearly constant speed, so the mechanical losses do not depend much on the load, whether large or small. They do depend very greatly on the condition of the bearings and brushes.

Copper losses are due to the flow of current against the resistance of the field and armature windings. They are therefore divided into two parts, field copper loss and armature copper loss. The former is also called "excitation loss." Since the field coils have resistance (usually high) some heat is produced as the necessary current for magnetization is made to flow through them. Like all heat losses due to current in a conductor, the

heating is proportional to the square of the current, being in watts,

$$W=I_f^2R_f$$

where I_f is the current in amperes in the field coils and R_f is the resistance of the whole field circuit.

To get the same terminal voltage at the armature, when the current in the latter is large, requires more magnetization than when the armature current is small. This in turn requires more field current, hence the field copper loss, or excitation loss, is somewhat greater at large loads than at small loads; that is, it varies somewhat with the load.

Like the field loss, the armature copper loss is of the I^2R type; it varies as the square of the armature current, and therefore as the square of the load on the generator. The armature resistance is made as small as is expedient. In a large generator it may be only a small fraction of 1 ohm, but the loss due to the great current generated will nevertheless be considerable.

Core losses, or losses in the magnetic circuit, are of two classes, due to "hysteresis" and "eddy currents." Hysteresis losses are caused by the rapid reversals of the magnetism of the armature core. Each molecule of the core may be regarded as a tiny magnet, and when the magnetization of the core is changed in direction the molecules have to be pulled around against their mutual magnetic attractions. It takes energy to accomplish this. In an electric machine there is a double reversal during each cycle. This makes many

reversals per second and requires considerable power.

Eddy currents are little electric currents induced in the iron sheets of which the armature core is made up. The thinner the sheets the smaller are the currents; in fact, it is because of the eddy currents that the core has to be laminated.

Both hysteresis and eddy currents produce heat in the core, and in producing heat they use up power which has to be furnished by the prime mover. Therefore they are wasteful, and the designers of electric machinery plan to keep them as small as possible.

No specific statement can be made regarding the magnitudes of the various losses described in the preceding paragraphs, because they depend on many factors, such as the size, the operating speed, and special features of design. But in order to give the reader some idea, it may be said, roughly, that at full load, for generators of the usual types, the mechanical or frictional losses may range from 6 per cent for a 1-kw. machine to 1 per cent for the 1000-kw. size; the excitation loss, from 6 to 1 per cent; the armature resistance loss, from 4 to 1 per cent; and the core loss, from 4 to 2 per cent.

It will now be clear why the allowable power output of a generator has a limit. Usually machines are heavy enough to give a large margin of strength, but they can not well be made large enough to allow for the heat produced by severe overloads long continued. The increased current causes heat to be produced more rapidly, and the temperature rises. High temperature is injurious

to the insulation. For example, it is found that cotton should not be continuously heated as hot as the boiling point of water. Cotton is the usual insulation for the copper wires used in machinery. If the insulation is spoiled, the current can follow other paths than those it should, and the machine is ruined.

Practically all electrical apparatus, whether for alternating or for direct-current generator, motor or other device, is designed for certain definite conditions of operation. It is standard commercial practice to attach firmly to every electrical machine before it leaves the factory a brass in-

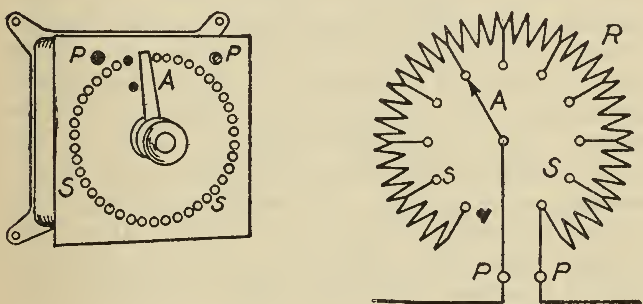


FIG. 15

formation tag called a "name plate." This usually gives the serial number by which the machine can be identified; tells the maker's name; states whether the machine is a generator or a motor; what is the maximum continuous power output; whether for direct or alternating current; if alternating, for what frequency and how many

phases; at what speed it is to be operated; at what voltage; the maximum current for continuous operation. Some of these items are at times omitted, but most of them are essential. A person who wishes to become familiar with electrical machinery should form the habit of examining the name plate of every machine to which he has access and note the differences in size, construction, and use.

It has been previously said that electrical power is measured in watts (or kilowatts, "kw.," when large). In a direct-current circuit watts are the product of volts times amperes. With alternating current something else has to be taken into account, and to get the average power we must multiply the volts-times-amperes by the "power factor." We might expect to find a. c. machines rated in watts or kilowatts, but if we look at the name plate of a generator we are likely to find the letters "kva." (kilovolt-amperes). That is, instead of actual watts the permissible output is expressed as a product of amperes times volts divided by 1000. The reason is plain, if we remember that the whole question of what an electric machine will stand hinges altogether on the heating.

The heating of the field coils and armature core depends upon the voltage generated, because that is determined by the strength of the magnetic field, which in turn depends on the current in the field coils. The heating of the armature conductors is determined by the armature current; whether or not that is in phase with the emf. makes no difference. The total heating, then, depends on the volts and the amperes, regardless of

the power output, which may be large or small, depending on the phase relation between the two.

Direct-current generators are usually rated in kilowatts and, as just stated, alternating-current generators in kilovolt-amperes. Motors, either d.c. or a. c., are often rated in units of horsepower (1 horsepower=746 watts). When an a.c. motor is rated in horsepower, a particular power factor is, of course, assumed.

The ratio of the useful output of a device to its input, is called its "efficiency."

In all kinds of machinery it is impossible to avoid some losses of power, so the output is less than the input and the efficiency is less than 100 per cent. It is lower for small electrical machines than for large ones, and for a given machine it varies with the extent to which the machine is loaded. Certain losses go on regardless of the load; those are the mechanical losses, field excitation, and core losses. Others increase with the load; the armature copper loss rapidly, some additional core losses and a portion of the excitation loss more slowly. When the output is small, most of the power input is used up in the constant losses, and the efficiency is low. With very large outputs the variable losses become excessive, again lowering the efficiency. For some intermediate load, usually not far from the rated load given on the name plate, the efficiency is a maximum. At full load, and for the usual designs, it may range from 80 per cent for a 1-kw. generator to 95 per cent for a 1000-kw. generator.

Electric generators are, with few exceptions, intended to be operated at constant or nearly constant speed. Assuming that the speed is constant,

and that the field excitation is also constant, the generated voltage would likewise be constant, regardless of the current output, if it were not for certain disturbing influences. A generator operating under these conditions is often called a "constant potential" or "constant voltage" machine.

The current output depends on what is going on in the external circuit. In a city it might depend on the number of lamps turned on. In the case of a generator supplying energy to a spark gap, it would depend largely on the adjustment of the

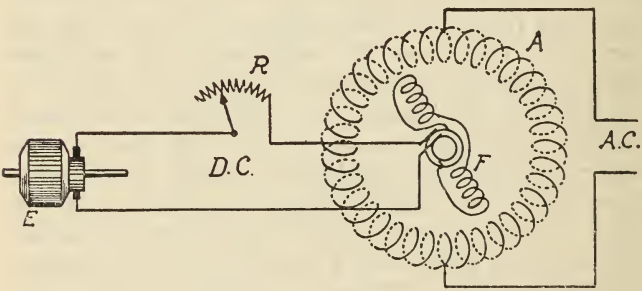


Fig. 16

gap. The term "load" is commonly used in this connection. Sometimes it means the devices themselves, which are connected to the line, and sometimes the current taken by them. There is generally no trouble in knowing which is meant.

Suppose we have a certain voltage generated when the load is zero. Then, if the machine is made to supply current to a circuit, the voltage at its terminals will in general be lowered and the greater the current, the more will the voltage

be reduced. The term by which the behavior of a generator is described in this respect is called the "regulation." It is found by subtracting the voltage at full load from the voltage at no load, dividing by the full load voltage and multiplying by 100 to get the result in per cent.

Expressed as a formula—

$$\text{Regulation} = \left(\frac{V_o - V_f}{V_f} \right) \times 100 \text{ per cent.}$$

where V_o = voltage at no load and
V_f = voltage at full load.

A small percentage regulation means that the

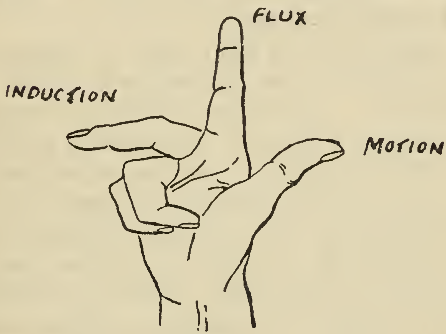


FIG. 17

voltage remains very nearly constant when the load is changed.

There are two reasons why the voltage of a generator is lower when it is supplying current than when it is not supplying current, even if the speed is entirely steady and the direct current flowing around the field magnets is the same.

(*a*) The armature windings are bound to have some resistance and some reactance. It requires an emf. to send current through the armature, therefore. This emf., called the armature impedance drop, has to be subtracted from the emf. generator to get the emf. left to send current through the external circuit. The greater the current, the greater the armature impedance drop and the less the emf. left for the external circuit.

(*b*) The armature winding and core constitute an electro-magnet. When current flows in the windings, the magnetic field caused by it is combined with the magnetic field due to field strength, with consequent decrease in armature voltage, since the resultant magnetic field is what determines the generated emf.

The change in the field flux by reason of the current flowing in the armature is called "armature reaction." Armature reaction occurs in direct current as well as in alternating current machines, and in motors as well as generators.

The reduction of terminal voltage due to the current flowing in the armature depends not only on the magnitude of the current but also on its phase relation to the emf., which is indicated by the power factor. A lagging current causes a greater reduction in terminal voltage than the same number of amperes in phase, the effect increasing with the lag. Thus, at 80 per cent power factor it may be twice as great as at 100 per cent. Conversely, a leading current, such as is taken by condensers, improves the regulation, so that the terminal voltage may actually be higher when current is flowing than when there is none.

Since the emf. is proportional to the rate of cut-

ting of flux, it follows that fluctuations of speed are attended with proportional fluctuations of voltage, provided the field excitation is not changed at the same time.

ELECTRICAL RESISTANCE

THE RHEOSTAT

The question of electrical resistance as applied to the projection circuit has long been a stumbling block to a great number of operators. While we admit that the subject is complicated, and some of its phases hard to follow, it is essential that the theory of electrical resistance be mastered if we are desirous of progressing in the art of projection.

Electrical resistance is that property of anything in an electric circuit which will resist the flow of current. The effect of resistance is to produce heat.

The unit of electrical resistance is the ohm, and is so named after Dr. G. S. Ohm, who gave us the series of formulas now known as Ohm's Law; it will be necessary to thoroughly understand the working of this law to be able to work out any of the numerous problems in electrical resistance. Ohm's Law states that: The current is directly proportional to the voltage and inversely proportional to the resistance. This means that if the voltage of a circuit be increased the current will proportionally increase, and should the resistance of a circuit be increased then the current will be proportionately decreased. Should the voltage be decreased there will be a proportional decrease in the current, if the resistance in the circuit is de-

creased there will be a proportional increase in current. Expressed mathematically

$$\text{Current} = \frac{\text{Electric Motive Force}}{\text{Resistance}}$$

Current is equal to the Electric Motive Force (Voltage) divided by the Resistance (in ohms) or

$$C = \frac{E}{R}$$

If by dividing the voltage by the resistance we get the amount of current, then by dividng the voltage by the current we will naturally get the amount of resistance in our circuit, or—

$$R = \frac{E\,M\,F}{C}$$

and so to find the voltage all we have to do it to multiply the current by the amount of resistance in our circuit, or—

$$E\,M\,F = C \times R$$

It will thus be seen that provided we have two known quantities the third unknown quantity can easily be obtained by the use of one of the above formulas; for instance, let us suppose that we have a line voltage of 100 and our circuit has a total resistance of 5 ohms, then by dividing the 100 (volts) by 5 (ohms) we find our current to be 20 (amperes).

Provided we knew there was a line voltage of 100 and we were drawing 20 amps at our arc, then

by dividing the 100 (volts) by 20 (amperes) we would get the amount of resistance in our circuit which would be 5 (ohms).

By the foregoing it is evident that the amount of current we will get at the arc depends on the E M F and the amount of resistance in our circuit.

Resistance is the inverse to conductivity.

Current encounters resistance when passed over any conductor. Copper, silver and aluminum are good conductors, so offer very little resistance, while metals like iron and German silver are poor conductors and offer a much higher resistance to the flow of current.

The resistance of any conductor increases as the length of the conductor is increased, as the diameter of the conductor is decreased; or as the temperature of conductor is increased (the resistance of insulating material and carbon decreases with an increase of temperature). To find the resistance of a copper wire, multiply its length in feet by 10.5 and divide the product by its area in circular mills.

Resistance is introduced into our projection circuit for two reasons, first to bring the supply voltage down to a suitable voltage for maintaining an arc and secondly to act as ballast on our line.

The voltage supply generally runs around 220 or 110 volts and as we only need approximately 50 volts to maintain a D.C. arc (for A.C. the voltage should be 35-40 volts) it is apparent that we must introduce some medium to act as a resistance to secure the desired voltage across the arc. This is generally accomplished by connecting a rheostat or a number of rheostats on our line in series with

the arc. The majority of operators are thoroughly familiar with the construction of the various makes of rheostats now on the market, but for the benefit of those who are not, let us here explain their general construction and operation.

A rheostat is constructed of a number of metal coils or grids (these coils or grids are made of

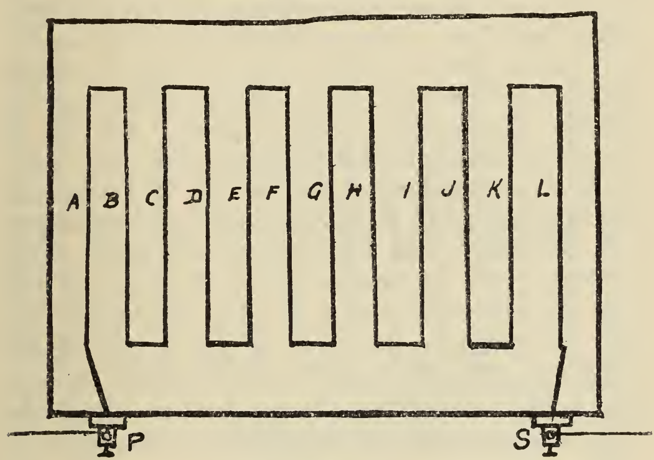


FIG. 18

some metal offering high resistance to the flow of current over them, generally iron or German silver) connected in series, these coils or grids are mounted on a metal frame from which they are insulated, the whole thing being covered with a perforated metal cover. The first and last coil are each connected to a terminal which allows for the connection of the conductors (see Fig. 18) The current enters the rheostat through terminal P, then passes through the coil or grid A to B,

then to C and so on till it has passed through each of the coils in turn and leaves the rheostat through terminal *S*. Most of the rheostats manufactured to-day are of the adjustable type, so constructed that by the turning of an adjustable level a number of the coils can be cut in or out of the circuit, thus cutting in or out resistance, thereby lowering or increasing the amperage at the arc. Fig. 19 is an elementary drawing showing how this is accomplished. P. is the terminal through which the current enters the rheostat, S the terminal through which it leaves after having passed through the series of coils or grids. As will be seen by referring to the diagram (Fig. 19) it depends on which contact points 1, 2, 3, 4 or 5, the adjusting lever N is placed as to the number of coils through which the current will pass. With the lever "N" or contact No. 1 the current will pass through coils A B C D only, by turning the lever to contact 4, two coils K and L will be cut out of the circuit; while if lever is placed on contact 5 the current must pass through all of the coils or grids before leaving through terminal S.

Rheostats are always marked for the voltage they are to be used on and the amount of current they will give at the arc. A rheostat marked 110 volts, 40 to 65 amperes simply means that providing it is connected on a 110 volt line it will give 40 amperes at the arc with the lever on low contact point, 65 amperes if the lever is placed on high. Two or more rheostats can be connected together in series or multiple, but remember that rheostats must always be connected in series with the arc.

Figure 20 shows two rheostats connected in series with each other and in series with the arc. Fig. 21 shows two rheostats connected in multiple with each other and in series with the arc.

Never under any circumstances connect 110 volt rheostat either singly or in multiple on a 220 volt line, as the coils will be heated above their

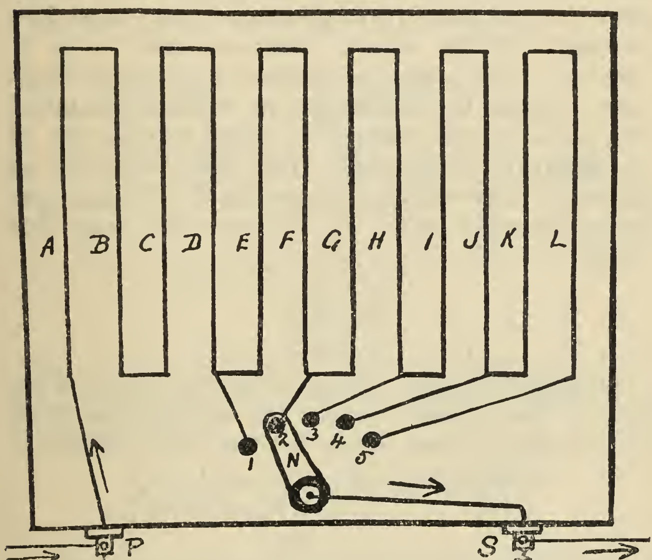


FIG. 19

rated capacity and probably will burn out. However two 110-volt rheostats if connected in series with each other can be used on a 220-volt line until such time as a 220-volt rheostat can be obtained.

Where a number of rheostats are connected together in series the resistance in our circuit is

equal to the sum of the separate rheostats. So by taking three rheostats that have a resistance of 4, 6 and 10 ohms, respectively, and connecting same in series with each other and in series with the arc, we would have a total of $4+6+10=20$ ohms resistance from the three.

Resistance in Series.—If several rheostats are connected as shown in Fig. 20, so that whatever current flows through one of them must flow through all the others, they are said to be in "series." The single equivalent resistance which may replace the entire group without changing the value of the current is equal to the sum of the separate resistances. This may be proved as follows: The voltages across R_1, R_2, R_3, etc., may be represented by E_1, E_2, E_3, etc. We may then write

$$E_1=R_1I$$
$$E_2=R_2I$$
$$E_3=R_3I$$

Since the over-all voltage between a and b is the sum of the voltages across the separate parts of the circuit, we may write for the total voltage E,

$$\begin{aligned} E=E_1+E_2+E_3 &= R_1I+R_2I+R_3I \\ &= I[R_1+R_2+R_3] \\ &= IR \end{aligned}$$

where R replaces the sum of all the terms in the brackets and is seen to be the sum of the separate resistances.

If a number of equal resistances are connected in series, we may write for the equivalent resistances of the group,

$$R=nr$$

where n is the number and r is the resistance of

each. *When resistances are connected in series, it must be remembered that the current through each resistance is the same and the total voltage is subdivided among the various parts of the circuit.*

Resistances in Multiple.—If several rheostats are connected as shown in Fig. 21, so that only a part of the current passes through each resistance, they are said to be conected in "parallel" or "multiple." The voltage E between points a and b is the same over any branch. We may then write, from equation

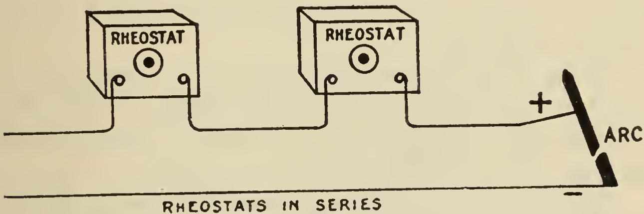


FIG. 20

$$i_1 = \frac{E}{R_1} \qquad i_2 = \frac{E}{R_2} \qquad i_3 = \frac{E}{R_3}$$

Since the total current must be the sum of the three branch currents, we may add the three equations and

$$i_1 + i_2 + i_3 = I = E\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$$

or

$$\frac{I}{E} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Thus, two resistances in parallel have a joint or equivalent resistance, given by the product of the resistances divided by their sum.

When there are a large number of single resistances, all of the same value, parallel, it can be shown that the equivalent resistance of the group is given by

$$R=\frac{r}{n}$$

where r is the value of one resistance, and n is the number of them.

When resistances are connected in parallel it must be remembered that the voltage, Fig. 21, *is constant, and the total current is subdivided among the several branches.*

Rheostats are extremely wasteful, being about 50 per cent efficient when new; the electrical energy is converted into heat which goes to waste. For instance, let us suppose that the supply voltage is 110 and that we are drawing 50 amperes at the arc, $110\times50=5{,}500$ watts registered on the meter and to be paid for. Our arc voltage is approximately 50 volts, so $50\times50=2{,}500$ watts, the amount actually used at the arc, $5{,}500-2{,}500=3{,}000$ watts wasted in the rheostat. As the line voltage is increased the percentage wasted is proportionately much greater.

Rheostats should be installed outside the projection room wherever possible, preferably on a shelf near the ceiling and located near enough to the vent to allow the heat from the rheostat to be carried to the open air. They should be kept

away from anything inflammable. Where the rheostat is located away from the projector it is advisable to have a control switch so placed that the operator can cut in or out resistance without having to leave his machine. All electric connections should be kept tight to prevent arcing; remember copper oxidizes under excessive heat and additional resistance is thus added to the circuit.

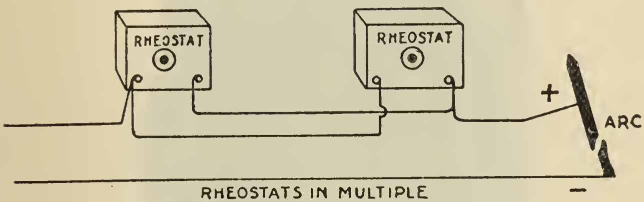


FIG. 21

MULTIPLE UNIT RHEOSTATS

A multiple rheostat consists of several independent rheostats arranged in a housing; each unit is a separate arc rheostat, delivering two and one-half amperes at an arc voltage of 58. In the event of any unit burning out the balance are still oper-

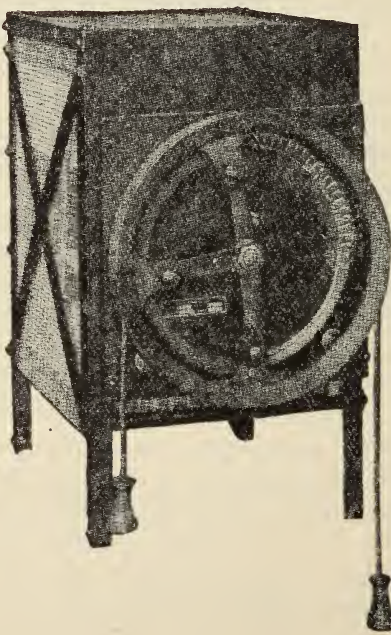


FIG. 22
Robin Multiple Rheostat

able. Each rheostat consists of from 10 to 40 units, depending on the capacity. Rheostats used on big installations are arranged for remote control, the control panel board with radial multiple switch is placed in the front wall of booth under the look-out port holes.

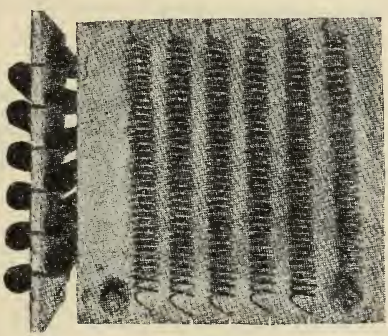


FIG. 23
Separate Unit of Robin Multiple Unit Rheostat

NEW DEVICE FOR CONTROLLING RESISTANCE

A patent has been granted for an electrical regulating switch for limiting the current in two separate circuits to a predetermined maximum. The invention relates to a new or improved regulating switch and is particularly adapted for use in connection with motion-picture projectors, especially in cases where two or more machines

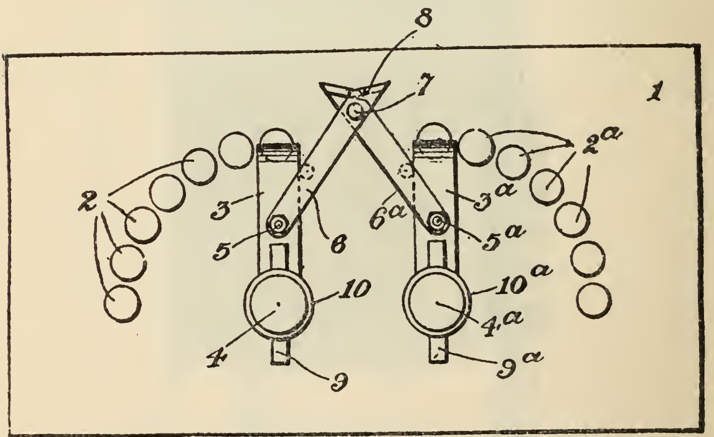


FIG. 24

are used. The object of the invention consists in a new or improved arrangement whereby the amount of current switched on in either one or two arcs, is limited to a predetermined maximum.

According to the inventor the switch arms for each set of resistance are arranged to move over

the usual radially arranged contact studs, preferably disposed side by side or one above the other. These switch arms are connected by two hinged or pivoted connecting members, the inner ends of each of which are pivoted to one another, while their opposite ends are connected to the respective switch arms. The inner ends of each of the connecting members are provided with projecting stops, each arranged to engage the opposite member and thus limit the stroke or extent of rotation of either switch arm relatively to the other.

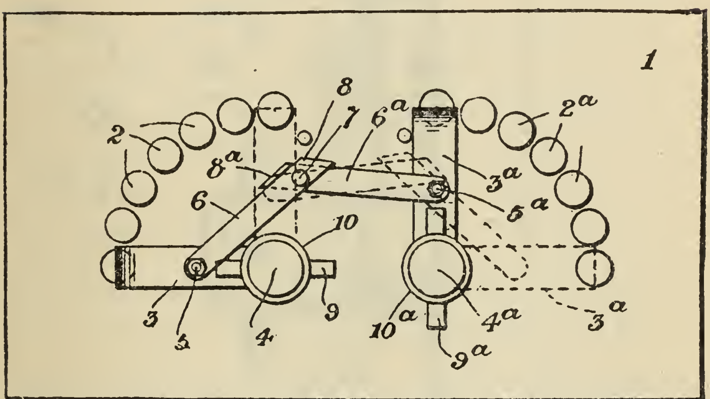


FIG. 25

In order that the invention may be readily understood, reference is directed to the accompanying drawings, which show by way of example, a switch constructed according to the invention, in which: Figures 24 and 25 are front elevations of part of a switchboard showing the switch arms for the two sets of resistances in varying positions.

Figure 26 is a part and elevation of Figure 25 seen from the left. The switchboard 1 is provided with two sets of radially disposed contact studs 2, 2a, connected in the usual manner to two sets of resistances (not shown in the drawings). Each set of contact studs is provided with a switch arm 3, 3a, pivotally mounted on the switchboard at 4, 4a, respectively. The switch arm 3 has pivoted

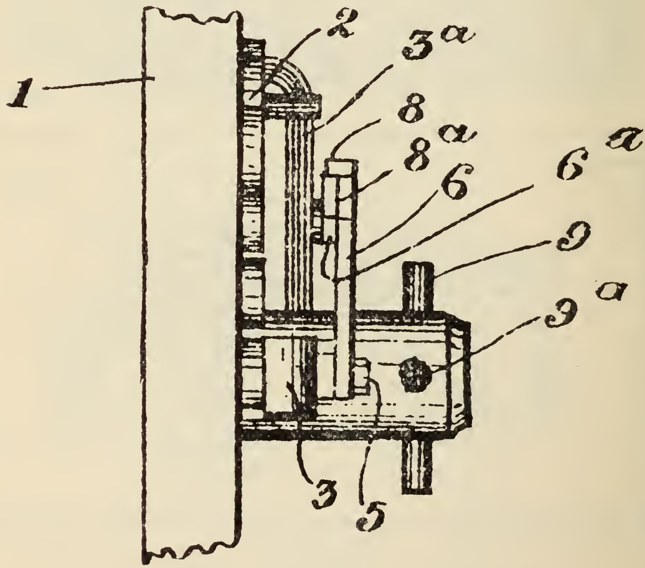


FIG. 26

thereto at 5 one end of a connecting member 6, while the switch arm 3a has pivotally connected at 5a one end of a connecting member 6a.

The members 6 and 6a are connected at or near their inner ends by a pivot 7. The member 6 is provided at its extreme inner end with a back-

ward projection stop 8 located in such a manner as to engage one edge or side of the member 6a, while the member 6a is provided at its inner end with a forward projecting stop 8a arranged to engage one edge of the opposite member 6. Each of the switch arms is provided with an operating handle 9, 9a, secured at or near the front end of the rotatably mounted holders 10, 10a, respectively.

The operation of the apparatus is as follows: When the switch arms 3, 3a, are in the position shown in Fig. 24, both are in the zero position in which no current is passing through either of the resistances. If it is desired to switch on the arc, connected with the contact studs 2, the switch arm 3 is rotated in an anti-clockwise direction, that is, into the position shown in full lines in Fig. 25 in which position the maximum amount of current is switched on in one circuit, while no current is passing in the other. If now it is desired to switch on the current in the circuit connected with the contact studs 2a, the switch arm 3a will have to be rotated in a clockwise direction as will be readily understood. The stops 8, 8a, on the inner ends of the members 6, 6a, are so arranged that the maximum movement of the switch arms is reached, when for instance, one arm is moved to the position in which the full current is allowed to pass and the opposite arm is in zero position. If the switch arm 3a is now rotated in a clockwise direction, the opposite arm 3 will be moved back towards its zero position, to a corresponding extent to which the switch arm 3a is advanced.

If it is desired to switch on full current in the circuit connected to the contact studs 2a, the switch arms will assume the position shown in dotted lines in Fig. 25, in which the switch arm 3 is returned to its zero position.

THE STEP-DOWN TRANSFORMER

To a great many projectionists the working principle of a transformer is a mystery, whereas it is one of the simplest electrical devices built.

A transfer is a device for changing the voltage and current of an alternating current circuit.

Transformers are spoken of as Step-up and Step-down transformers. It is the step-down transformer that is used for motion picture work, so that is the one we shall deal with in this article.

Step-down transformers are known under many trade names such as Economizers, Inductors, Compensarc's, etc.

The three essential parts of a transformer are two copper coils known as the primary and secondary, and a laminated iron core.

The core of the transformer is made up of a number of thin sheets of annealing iron; these sheets are very thin, generally running to one-hundredth part of an inch in thickness, the exact thickness depending upon the frequency of the circuit the transformer is to be used on. Each of the sheets is given a coat of some insulating compound, so that they are insulated from each other. The sheets are then built one upon the other in the form of a hollow square till a core large enough is obtained, the sheets are then clamped together and are insulated with mica or some other insulating material, so that the two copper coils may be wound around the core without the copper wire of the coils coming in contact with the iron core. Figure 27 is a diagram of an ele-

mentary transformer, showing the primary coil wound around one leg of the core and the secondary coil wound around the opposite leg.

When we close the circuit on the primary side of transformer the current passing through the primary coil magnetizes the iron core, this magnetism in turn induces an A. C. current in the secondary coil. So that while the primary and secondary coil are insulated from the core and

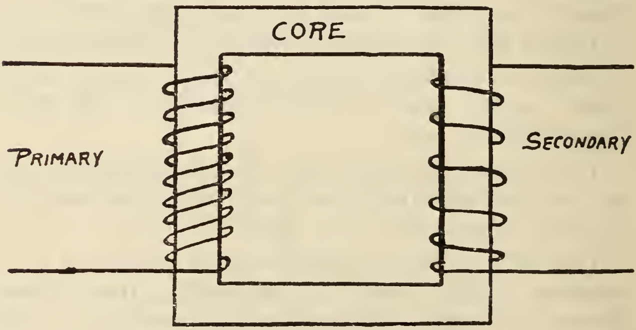


FIG. 27

from each other, there is a magnetic connection between both coils and core.

If we turn back to the basic principle of induction the working principle of the transformer is made clear.

If an A. C. current is passed through a conductor encircling a bar of soft iron, the iron will become a magnet and remain so just as long as current is passed through the conductor.

If a bar of iron carrying a conductor around it, be magnetized in a direction at right angles to the

plane of the conductor a momentary E. M. F. will be induced in the conductor; if the current be reversed another momentary E. M. F. will be induced in the opposite direction in the conductor.

The pressure induced in the secondary coil depends on the ratio between the number of turns in

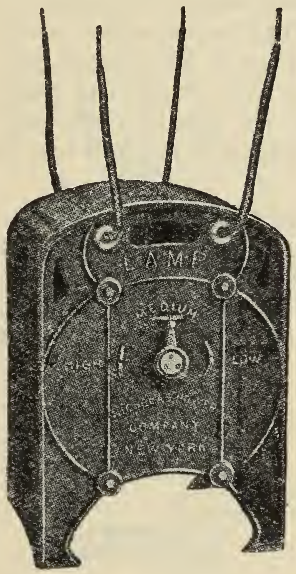


Fig. 28
Powers Inductor

the primary and secondary coils. Suppose the primary coil has (50) turns of wire and the secondary (5) turns, there would be a transformation ratio of 10 to 1, so if the primary coil was supplied with current at a pressure of 500 volts,

the pressure in the secondary coil would be one-tenth of this or $500 \div 10 = 50$ volts.

Now let us suppose that we have a flow of 20 amperes in the primary coil and that the ratio is the same (10 to 1), then $20 \times 10 = 200$ which equals the flow of current in the secondary coil.

On the primary coil we have 20 amperes at a pressure of 500 volts or $500 \times 20 = 10{,}000$ Watts or 10 K. W. On the secondary we have 200 amperes at a pressure of 50 volts or $200 \times 50 = 10{,}000$ Watts or 10 K. W. So we see that the wattage on the primary is equal to the wattage on the secondary, assuming that there is no loss in transformation.

We know that there are two forms of losses in all transformers, the iron or core loss and the copper or coil loss. These losses total about 10 per cent. The core losses are going on as long as the switch on line side of the transformer is

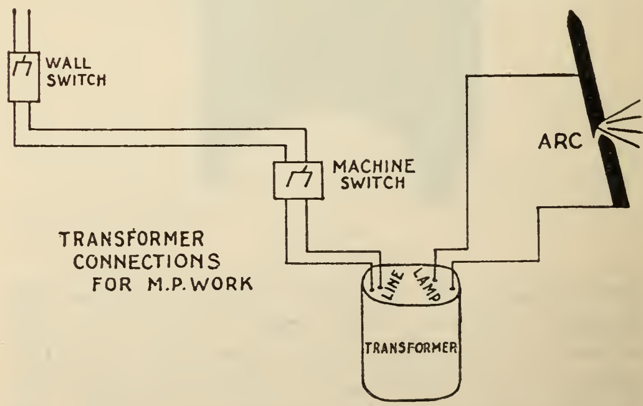


FIG. 29

closed; in other words while the transformer is carrying a no-load current. The copper losses only take place while the arc is burning or current is being drawn from the secondary coil.

Let us suppose the primary coil is drawing 20 amperes at a pressure of 100 volts, the wattage in the primary circuit would be $100 \times 20 = 2{,}000$ Watts. Let us assume that the losses in trans-

Fig. 30
Hallberg Economizer

formation is 10 per cent, this would mean that the wattage on the secondary circuit would be 2,000 Watts less 10 per cent or 1,800 Watts.

Transformers should always be connected between the machine switch and the arc lamp, so that when the machine switch is pulled, it stops a no-load current from passing through the primary coil of the transformer.

POINTS TO REMEMBER ABOUT TRANSFORMERS

Make sure that the primary coil (marked line) is connected to the source of supply.

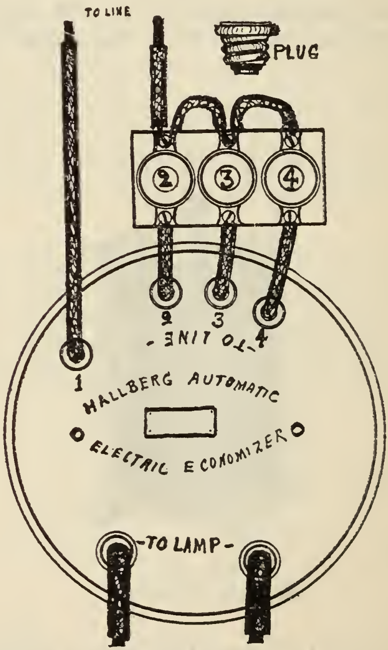


FIG. 31

See that transformer is connected between machine switch and arc lamp.

Do not use any resistance device in series with a transformer.

Make sure that all the connections are tight.

Cover all line terminals on transformer with tape.

Place transformer away from metal walls of booth.

Keep arc short.

See that voltage and cycles marked on transformer correspond with supply voltage and cycles.

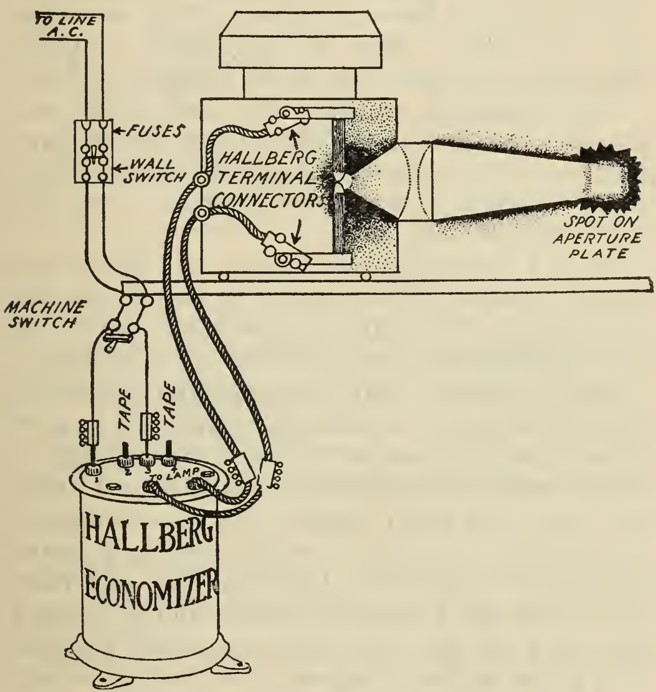


FIG. 32
Showing Economizer Connections from Wall Switch to Arc-Lamp

THE HALLBERG ECONOMIZER

The Hallberg economizer is simply a transformer of the semi-constant current type, taking A. C. current at line voltage and delivering A. C. current at arc voltage. Semi-constant means that it will take the line current at a fixed potential and will deliver from the secondary a steady amperage flow regardless of the length of the arc.

The economizer consists of a continuous rectangular core, on one leg of which is the primary winding, on the opposite core leg is the secondary which is made of larger cross section wire, this coil is connected to lamp.

On 110 volts the economizer line wires are usually attached to terminals 1 and 2 for any voltage from 100 to 105, to 1 and 3 for 110 volts or to 1 and 4 for voltage between 115 and 210.

Some operators desire varying candle power at the arc lamp to accommodate lighter or more dense films; in a case of this kind, it is possible to simply install a three pole main line cut out (with one single fuse plug) connected to the economizer. By placing the plug in socket No. 2, a heavy amperage is obtained. Unscrew plug and place in 3 and we get a medium current, and if we place plug in 4 we get the lowest amperage possible. This gives us three degrees of amperage at arc. By installing more than one fuse at a time we would blow the fuse, as this would be short-circuiting the primary coil.

When using the Hallberg economizer:

1. Place economizer at least 12 inches away from sheet iron walls, as otherwise there will be a humming noise.
2. 30 amperes line fuses are large enough for 110 volts and 15 amperes for 220 volts.
3. Connect fuses, switches and wires exactly as illustrated.

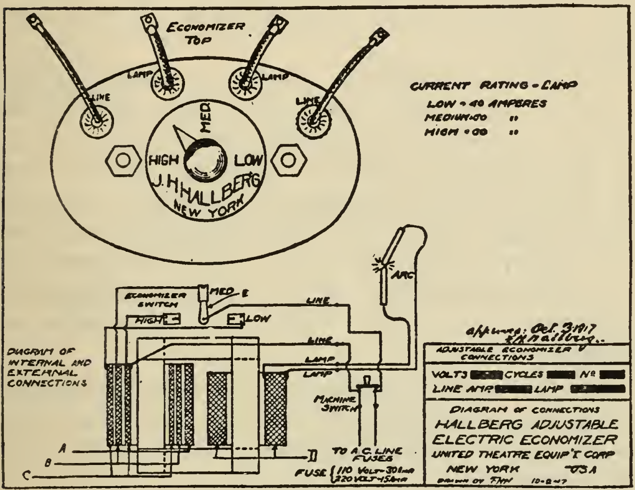


FIG. 33

4. Make sure that all connections are tight, especially at the carbon clamps in the lamp house.
5. Cover all line terminals on economizer with tape.
6. Use only ⅝ inch soft carbons cored.
7. Feed carbons often and a little at a time.
8. Keep arc short, not over 1/32 inch.

INSTRUCTIONS FOR INSTALLING AND OPERATING A-C. TYPE "A" COMPENSARC

The compensarc is a self-contained device and requires no auxiliary rheostat or other controlling mechanism. It should be mounted near the picture machine, so that the switch is convenient to the operator.

Before installing the compensarc examine the name plate to see if the rating agrees with the cycles and line voltage of the circuit from which it will operate. Connect both wires from the operating circuit to the two terminals marked "line," and from the two terminals marked "lamp" connect the wires leading to the terminals of the picture machine lamp. As this is an alternating-current device, there are no positive or negative wires.

The primary or line wires should be fused with a fuse about half the size of the maximum current at the lamp. This would ordinarily require about 30-ampere fuse.

This device is adjustable in three steps, which three steps have been found to meet the general service conditions. When the switch is open no current flows through the lamp, so the operator can freely take out the carbons and make any adjustments required without opening the line switch.

Throwing the switch blade in contact with clip No. 1 gives an adjustment so that with the carbons

separated about 3/16 in. the current supply is approximately 30 amperes, which gives a light suitable for light films or a short throw. In contact with clip No. 2 the adjustment changes so that approximately 40 amperes flow through the lamp. This is the usual operating position of the compensarc switch and gives a powerful white light which is found to be best adapted for all films.

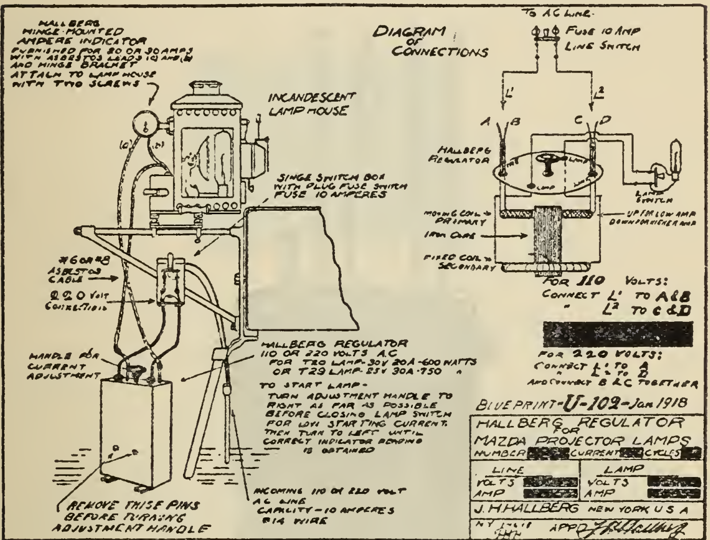


FIG. 34

Hallberg Automatic 4 in 1 Mazda Lamp Regulator

Throwing the switch blade over to clip No. 3 allows approximately 60 amperes to flow through the lamp. This gives an intense light and is required only where the films are very dense or the throw is very long.

The alternating-current compensarc is a transformer device for use on alternating-current circuits which cuts down the current supply on 110-220 volts, with the voltage required at the arc approximately 35, in an efficient manner, the efficiency being exceedingly high as compared with the rheostat, which wastes all of the energy between 110 and 35 volts, converting this energy into heat.

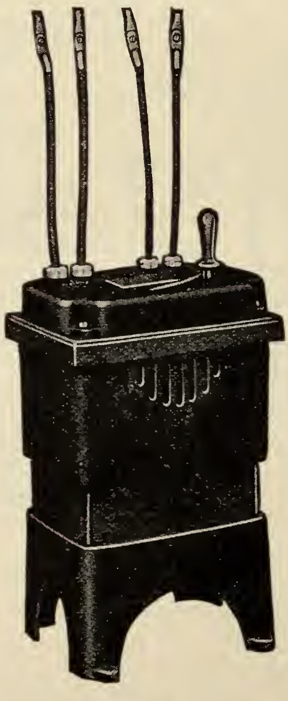


Fig. 35
A-C Compensarc

In order to determine if your compensarc is in good condition on all three steps, first, start an arc on any one of the steps, then jump the switch quickly to the other two steps in succession, watching the light. There should be an appreciable difference in the light, which you can very readily detect in trying this one or two times.

On account of the efficiency of the compensarc there is so little energy converted into heat that the outfit can be installed in the operating room,

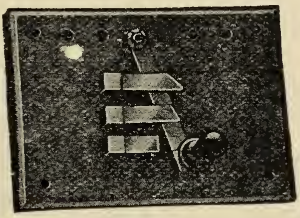


FIG. 36

Slate Top of A-C Compensarc Showing Switch Blades

whereas it would be impossible to do the same with the rheostat. If you think the compensarc is heating up, do not attempt to determine the temperature with your hand, but put a thermometer on it on the hottest part for about five or ten minutes, and then take a reading of the thermometer. Temperature rise should never exceed 40 deg. C. or 72 deg. F.

If you observe some of the following points, you will be pretty sure to get good results:

1st—Make sure that the two leads marked

"lamp" are connected directly to the lamp of the picture machine. It is not necessary to select for positive or negative leads.

2nd—The other two cables coming from the compensarc should be connected to the line direct.

3rd—Never connect any resistances up with the compensarc on either the lamp or the line side. The compensarc is intended to cut out all resistances. Be sure the line voltage and frequency agree approximately with the line voltage and frequency marked on the name plate on the compensarc.

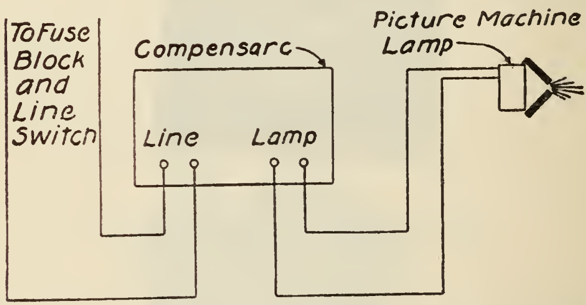


FIG. 37

4th—Be sure that all connections from the line to the lamp terminals are tightened up and see that the switch has not been damaged in shipment. In every case try to get the best results on the given current that you possibly can by focusing the arc in relation to the lens. This can only be determined by trial. If you operate the arc too closely to the condenser lens you are apt to crack it.

Do not try to run any more current in the lamp than necessary for the light required. A ⅝-in. carbon will operate very satisfactorily on 40 amperes, with about a 3/16 in. separation. Very much more current than this will tend to produce noise at the arc. This noise is not caused by the compensarc, but is caused by the alternating current in the arc and will be present no matter what kind of an outfit is used.

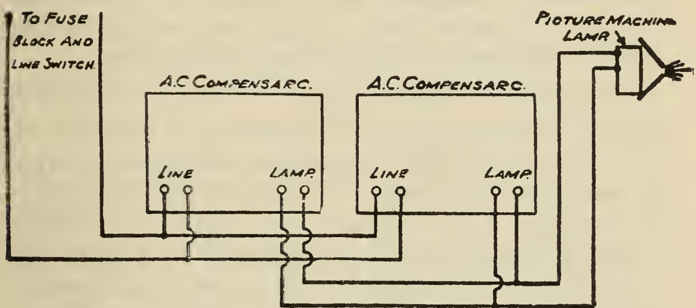


FIG. 38

A-C. COMPENSARCS IN MULTIPLE

In cases where more than 60 amperes of current is desired in connection with the motion-picture projection, two alternating-current compensarcs connected as shown in Fig. 38 can be used to give entirely satisfactory service. Two standard alternating-current compensarcs connected in this manner can be used to give a maximum of 120 amperes to the motion picture lamp. Eight values of current ranging between 30 and 120 amperes inclusive can be secured by this connection.

THREE-WIRE SYSTEM

A system of wiring for current distribution where three wires are used in place of two sets of two wires. The advantage of the system is the saving of copper and consequently the cost of wiring. By means of the three-wire system we are able to increase the pressure at which the current is transmitted, and take advantage of the greater efficiency of the lower voltage lamps.

A conductor rated to carry a current of 20 amperes, can carry that 20 amperes at a pressure of 10 volts or 10,000 volts, and as electrical energy is equal to the amount of current multiplied by the voltage, it will readily be seen that the transmitting capacity of a current can be greatly increased by increasing the voltage without increasing the size of the conductor. However, incandescent lamps are usually made for use on a pressure of 110 volts, so it would be necessary to either cut down the voltage to this pressure or connect a number of the lamps in series to take care of the extra pressure.

Fig. 39 shows two 110 volt dynamos A and B supplying two independent circuits. In each case five 110 volt ½ ampere lamps are connected across a 110 volt circuit, each dynamo supplying 2½ amperes at a pressure of 110 volts; which means a total wattage of 550 W. for the ten lamps. Fig. 40 shows us the same two dynamos, now connected together in series, and the same ten lamps, this

time connected in series of pairs across a potential of 220 volts (on account of the dynamos being connected in series). As the voltage in this case is just double each lamp now draws $\frac{1}{4}$ ampere instead of $\frac{1}{2}$ ampere as in Fig. 39 which makes the wattage in this case $220 \times 2\frac{1}{2} = 550$ watts, thus the wattage in each case is the same, but in Fig. 40 we have made a saving of 100 per cent. in copper, as we used two wires only, against four in Fig. 39.

The arrangement in Fig. 40 is open to objection, however, as should one of the lamps burn out or

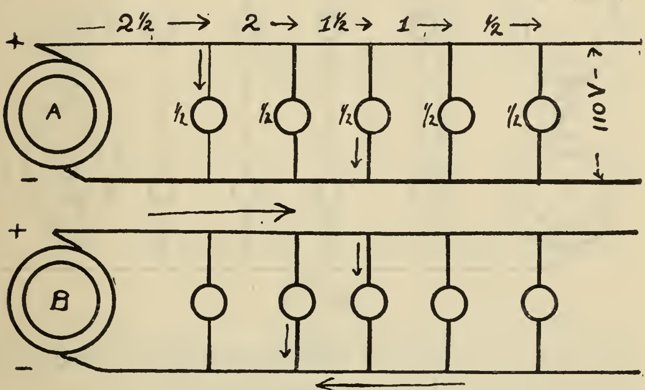


FIG. 39

be turned off, its companion will also go out. This is overcome in the three wire system by introducing a third wire into the circuit (Fig. 41) thus providing a supply or return wire to any of the lamps and permitting any of the lamps to be cut

out of the circuit without affecting any of the others.

The three wire system is generally obtained by connecting two dynamos of a like capacity in series and connecting a third or neutral wire to a point common to both dynamos. The dynamos being connected in series, we get the added voltage of the dynamos when connected between the two outside wires, and the voltage of one dynamo

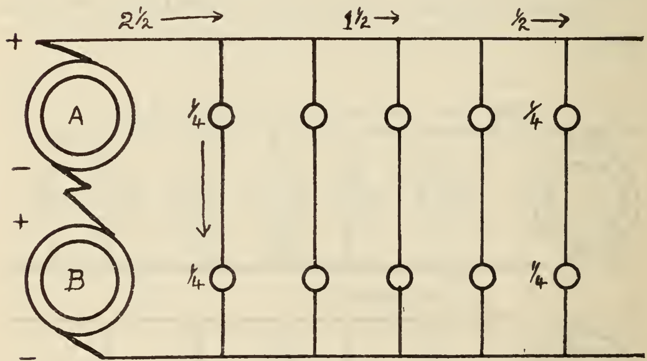


FIG. 40

only when connected between either of the outside wires and the neutral (Fig. 41).

No current will flow over the neutral wire, if the system is kept balanced (the same amount of amperage is drawn off either side of the system) and the flow of current in the neutral wire at any time is the difference between the amperage drawn from either side.

Fig. 42 shows a three wire system, A and B.

being two 110 volt dynamos connected in series, C is the positive wire, D the neutral wire and E the negative wire. The ten circles on either side of the neutral wire represent lamps, each taking one ampere, as we have the same amount of current (10 amperes) drawn off either side, the system is balanced and there is no flow of current in the neutral wire. The ten amperes being drawn from dynamo A over positive wire C and after

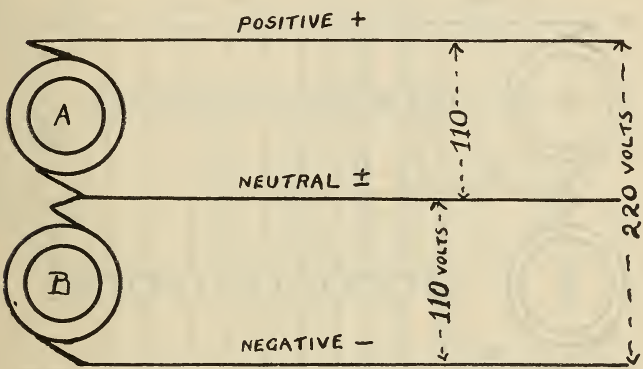


FIG. 41

passing through the lamps returning to dynamo B by way of negative wire E.

An unbalanced three wire system is shown in Fig. 43, taking it for granted that each of the lamps is taking one ampere, we have four amperes on one side and six on the other, $6 - 4 = 2$, so our system is unbalanced to the extent of two amperes, and this represents the flow of current in the neutral wire. Four amperes being drawn

from dynamo A over positive line C then after passing through the four lamps on the upper side, the four amperes goes to feed four of the lamps on the lower side, but as there are six lamps to feed on the lower side, the two extra amperes are drawn from dynamo B over neutral wire D (which under the circumstances acts as a positive). So in Fig. 43, we have four amperes flowing from

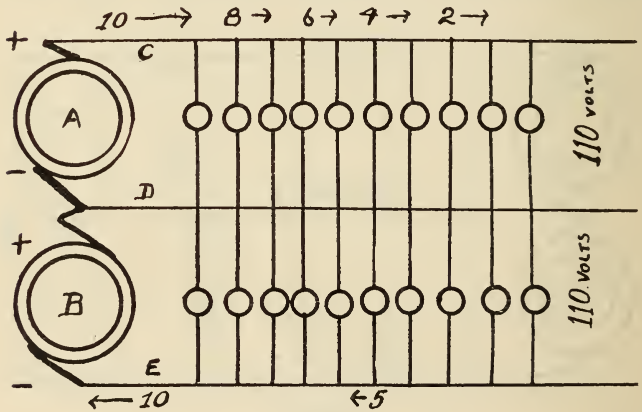


FIG. 42

dynamo A over positive line C, two amperes flowing from dynamo B over neutral wire D, and six amperes flowing to dynamo B over negative line E.

In Fig. 44 we have another unbalanced system, in this case six amperes are drawn from dynamo A over positive line C and after feeding the six lamps on the upper side, four amperes are used to

feed the four lamps on the lower side, the two extra amperes going back to dynamo A over the neutral wire D (which now acts as a negative) and four amperes going to dynamo B over negative line E.

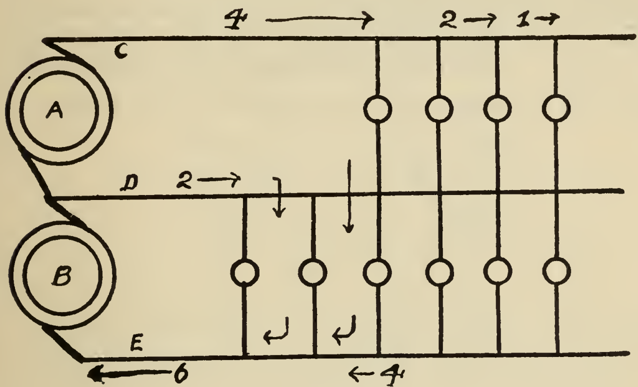


FIG. 43

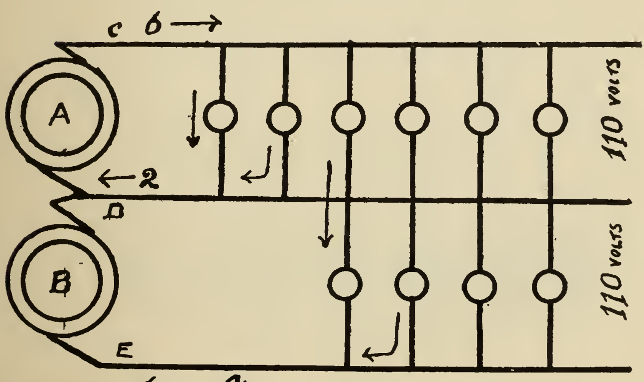


FIG. 44

With a three wire system, the idea is to keep the system as near balanced as possible. For motion picture work it is advisable to connect the machines between the neutral wire and the outside, one machine on each side of the system. When using the positive and neutral wires, the positive goes to the top jaw of arc lamp and the neutral to the lower, if you use the neutral and negative wires then the neutral wire goes to top jaw of arc lamp and the negative to the lower.

FUSES

A safety device used on your line to protect the circuit.

A short length of fusable wire introduced in a circuit so that if the temperature of circuit should rise above the rated capacity of fuse the wire will melt and thereby open the circuit.

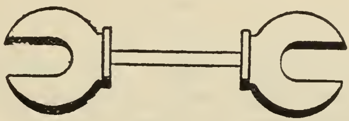
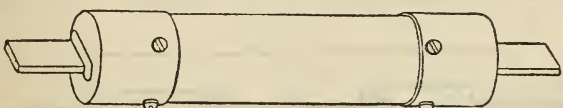


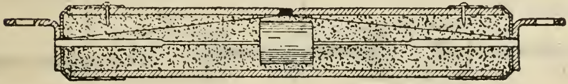
FIG. 45
Copper-Tipped Fuse Link

Fuses are made in different shapes and sizes, the moving picture operator, however, will only be called upon to handle the under-mentioned.

Link Fuse. The link fuse is the fuse always used in the booth, being of the open type it can-



Enclosed or "Cartridge" Fuse



Section of Enclosed Fuse

FIG. 46

not be readily boosted without same being plainly seen. Link fuses have no protective covering, so should always be installed in a metal cabinet.

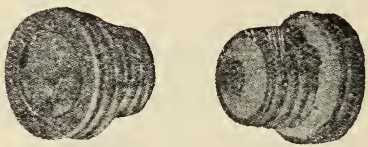


FIG. 47

Cartridge Fuse. Made by connecting two metal cap terminals with a short paper tubing. The two metal caps are connected by a thin wire which runs through the paper tubing, the tubing is filled with some non-conducting powder.

Plug Fuses. Plug fuses are used for protecting the house wiring and circuits carrying small amperage.

In fusing upon any circuit you must take into consideration the size of the wire used and the amount of amperage to be drawn. The fuse

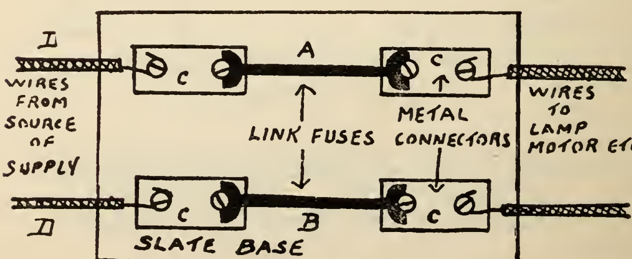


FIG. 48

should be rated under the carrying capacity of the wire with a sufficient margin to allow the required number of amperes to pass over without overheating. The rating of all fuses is marked on them. Never use a fuse not marked.

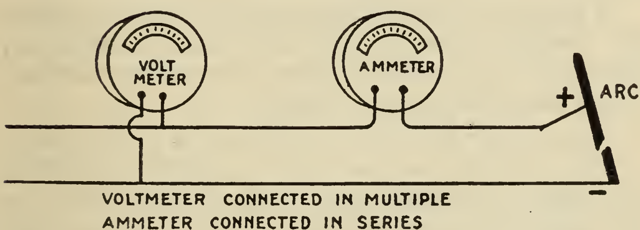


Fig. 49

TESTING FOR GROUNDS

Always remember that like poles repel each other while unlike poles attract each other, in other words the negative polarity is attracted by the positive polarity, and vice versa, while the negative has no attraction for negative nor the positive for positive.

The positive wire of one system will have no attraction for the negative wire of any other system except its own, nor will the negative of one system find any attraction in the positive of any other system.

A ground is merely the current from one polarity being attracted by the opposite polarity, through the ground of some conducting medium other than that in the circuit.

Supposing that we are working on a three wire system and our neutral wire is grounded, and that we take and connect one of the outside wires to the upper jaw of arc lamp, and we connect the neutral wire to the lower jaw (the neutral wire now acts as negative to the upper or positive wire). We now ground the machine by connecting the metal framework of machine to the conduit coming in booth. Our machine now becomes grounded on the neutral because we have made contact between the frame of machine and the already grounded conduit. Should we now connect our test lamp between the upper jaw of arc lamp and frame of machine or lamp house we will naturally get a light as we are connected between the two polarities of the system.

Now should the arc lamp become grounded (caused we will say by the mica insulation coming out of jaw connection) on the lower jaw it would mean that the system is grounded on the negative polarity and the arc itself is grounded on the negative polarity, and this may or may not blow the fuse. But should it be the upper jaw of lamp that becomes grounded then our arc would be grounded on the opposite polarity to that of the machine, and thus cause a short circuit.

To test for a ground in the lamp house, first disconnect the ground wire and connect the terminals of test lamp between the upper and lower carbons. We should now get a light, as we are connected between both polarities, this test merely shows that we have current in our lamp.

Connect the test lamp between the upper carbon and the frame of lamp house, if we get a light then our lower jaw is grounded, if we do not get light then take it for granted that lower is free from grounds.

Next test to see if the upper is grounded by connecting the test lamp between the lower jaw of arc lamp and the frame of lamp house, if we get a light then upper jaw is grounded. Always find the cause of ground and remove same at earliest opportunity.

Before using the test lamp see that lamp is alright and that it makes good contact in socket.

To test for a ground in the rheostat, use a bell set. First connect the terminals of bell set between the two binding posts of rheostat, and if rheostat is free from open circuits you should get a ring, next connect the terminals of bell set between one of the coils or plates in rheostat and

the iron frame, if you get a ring it signifies that the rheostat is grounded, but this test will not tell you which coil or plate is causing the ground. To find exactly where ground is, proceed as follows: connect bell set between the first coil and frame, if you get a ring, disconnect the first coil, now connect between the second coil and frame, if you get a ring disconnect the second coil, and do the same to third and fourth coil, keep testing in this manner till bell stops ringing, then the coil you removed last was the coil that was grounded, so if you have removed six coils and the bell stops ringing when connected between the seventh coil and frame, it was coil number six that was grounded.

If the rheostat is made of more than one section, test each section separately and find which section the ground is in, then proceed as above. This is to save time.

MOTOR TROUBLES AND REMEDIES

Sparking may be due to overload, wrong position of brushes, broken coil, weak field, and to any of the causes named for dynamos.

SPARKING

Symptom. Intermittent Sparking. On a varying load, in which the work comes on, at the beginning or end of each cycle, and then falls off during the remainder of the cycle, a motor often sparks just as the peak load comes on.

The cause is the heavy current taken at the instant of maximum load, which distorts and weakens the effective field and shifts the neutral point. This weakening of the field results in a still larger current in the armature, aggravating the evil.

Remedy. Add a compounding coil on the motor to assist the shunt, or exchange the motor for a compound-wound one, or one with interpoles.

FAILURE TO START

(1) *Symptoms.* Motor does not start. Little or no current passes on closing the D.P. switch and pushing starting handle over.

Probable Causes. Brushes not down. Switch not making contact in the jaws. Starting switch not touching the contacts. Fuse broken. Controller fingers not touching contact plates. Break in series coil (if a series motor). Terminal loose. No current on mains.

If the no-volt release coil excites, or if a long arc is observed on breaking circuit, it indicates

that the shunt field gets its current and the probable cause of the failure to start is that the shunt is connected in series with the armature owing to two of the leads from the starter being reserved.

Remedy. Trace out the connections or use testing set.

FAILURE TO START

(2) *Symptom.* Motor does not start, but takes excessive current. Fuse or overload cut-out acts.

Cause. It is assumed the motor is not overloaded; this can be tested by taking load off and trying to start motor light. If a shunt motor there may be a short circuit in connecting cables or in field coil; or in armature; or a break in field coil.

Remedy for broken field. If field excites when brushes are up, but not when they are down, the symptoms point to a short circuit in or across armature, or brushes.

Examine brushes for short circuit to frame, for copper dust, oil, or broken down insulation.

Then disconnect armature and excite field. Move armature round quickly by hand. A drag will be felt as the short circuited coils pass the poles. If the armature can be driven at a fair speed by belt, with the field excited, the short-circuited coils will warm up and can probably be located in this way.

If the above symptoms occur with a series-wound motor, the cause may be a short in the field or armature, but not a break.

A fairly common cause is incorrect connecting up.

Another cause, particularly with machines that

have been dismantled, is incorrect polarity of the field coils. Thus if the coils are connected up so that they are all of the same polarity, the effect is the same as with a broken field wire as the field is completely neutralized. If only one of the field coils is reversed in a four-pole motor, the motor would probably not start and would in any case take an excessive current.

Remedy. Test the coils for polarity.

INCORRECT SPEED

A certain amount of speed adjustment may be obtained by altering the position of the brushes. Moving the brushes backwards from the neutral point has the effect of increasing the speed, whilst moving them forward reduces the speed.

EXCESSIVE SPEED

Symptom. Motor starts, then speed gradually increases till motor runs at very excessive speed. This only occurs when a motor starts light or on a very light load such as a loose pulley.

Cause. If shunt or compound motor. Shunt coil connected in *series* with armature instead of in parallel.

On first switching on, the magnets excite, as the armature is stationary and allows the full shunt current to pass the coils. As the armature speeds up it puts a back E.M.F. in the circuit, gradually reducing the current passing and thus weakening the field. The faster the armature goes the weaker the field becomes. A short circuit in the shunt might produce same result if motor starts absolutely light.

Remedy. Connect up the shunt.

FUSE BLOWS

Symptom. Motor starts and runs up to its proper speed, but fuse or overload acts on putting load on.

Cause. This is a sign of overload. Probably belts too tight, bearings tight or dry.

If the fuse blows whilst starting up there may be a ground on the motor. This should be tested. If the starter is provided with shunt sector the fuse may blow whilst starting up, owing to a bad contact to this sector, due either to dirt or to a hollow place in the metal.

In the case of a compound-wound motor a cross connection or leakage between the series and shunt windings will cause the fuse to blow if the cross is in a position that the shunt is practically short circuited by the series.

STARTER OVERHEATS

Symptom. Motor starting against load takes excessive current. Last few coils of resistance overheat (probably smoke or get red hot). Fuse or overload acts, or motor sparks.

Cause. Overload; or starter too small.

When a motor starts against a load having considerable inertia, such as heavy line shaft with several large pulleys and tight belts, or against a heavily fly-wheeled machine, time must be given for it to get up speed. If the starter is moved over the contacts more quickly than the motor can accelerate, an excessive current will pass, causing the motor to spark. The starter must be put on more slowly and this will cause it to heat up unless it has been liberally rated.

Remedy. Exchange starter for one having more margin, that is one which permits of starting up slower. This does not mean a starter for a larger H.P.

STARTS SUDDENLY

Symptom. Motor does not start nor take current till most of resistance is cut out, then takes rush of current and starts suddenly.

Cause. A break in the starting resistance.

Temporary Remedy. Connect the contacts where break occurs, until resistance can be repaired.

WRONG DIRECTION

Symptom. Motor runs in wrong direction.

Remedy. Reverse armature or field connections, whichever is the easier, but not both.

In a compound-wound machine both the shunt and series coil must be reversed if the field be reversed; but if the machine be provided with interpoles these must be treated as part of the armature and must therefore not be reversed when the field is reversed.

MOTOR REVERSES

Symptom. Motor starts up and runs correctly on light load. On an overload, or reduced voltage, motor reverses and runs backwards.

Cause. This applies to a compound-wound motor, with the series or compound coil connected up in opposition to the shunt coil.

Remedy. Reverse the series coil.

FLASHING

Symptom. Severe sparking or flashing apparently all round the commutator; overheating of the armature and burning of the insulation between a couple of the segments.

Cause. The cause of the above is a broken wire in the armature winding.

Remedy. If the broken end cannot be located and repaired easily, the armature must be stripped until the break is found and the section re-wound. A temporary repair can sometimes be made sufficiently to enable the motor to continue working, by joining across the two segments on each side of the burnt mica with a short piece of copper wire, the wire being laid on the ears of the commutator and sweated in with a soldering iron. This practically converts two segments into one, and the motor will run in this way quite satisfactorily. If the commutator lugs are not readily accessible, a copper pin may be driven hard down between the two segments in a part not under the brushes.

FLASHING OVER

Symptom. On an overload and sometimes on a normal load a motor will flash from the brushes to a part of the commutator or to the rocker, and blow the fuses. This is more liable to happen with a weak field.

Cause and Remedy. The cause is that the motor has too much forward lead, and the brushes should be moved back a little.

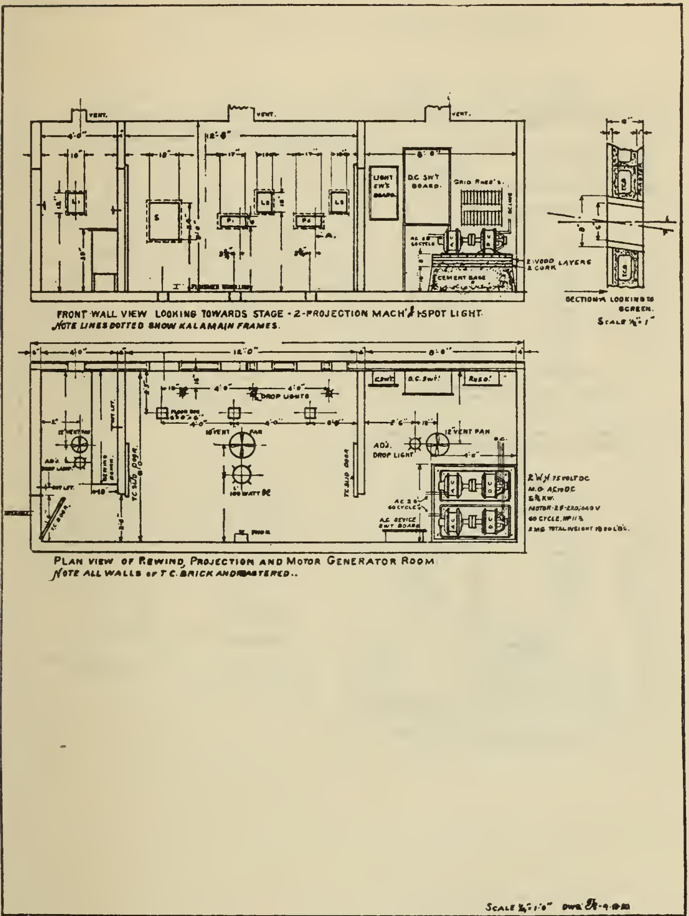

VENT.
VENT.
VENT.
LIGHT SW'T BOARD.
D.C. SW'T BOARD.
GRID RHES'S.
CEMENT BASE
LAYERS
FRONT WALL VIEW LOOKING TOWARDS STAGE - 2-PROJECTION MACH'S & SPOT LIGHT.
NOTE LINES DOTTED SHOW KALAMAIN FRAMES.
SECTION A LOOKING TO SCREEN.
DROP LIGHTS
12" VENT FAN
ADJ. DROP LIGHT
100 WATT DC
AC. DEVICE SW'T BOARD
D.C. SW'T.
RHEO.
M.G. AC TO DC
60 CYCLE.
PLAN VIEW OF REWIND, PROJECTION AND MOTOR GENERATOR ROOM
NOTE ALL WALLS OF T.C. BRICK AND PLASTERED..

FIG. 50

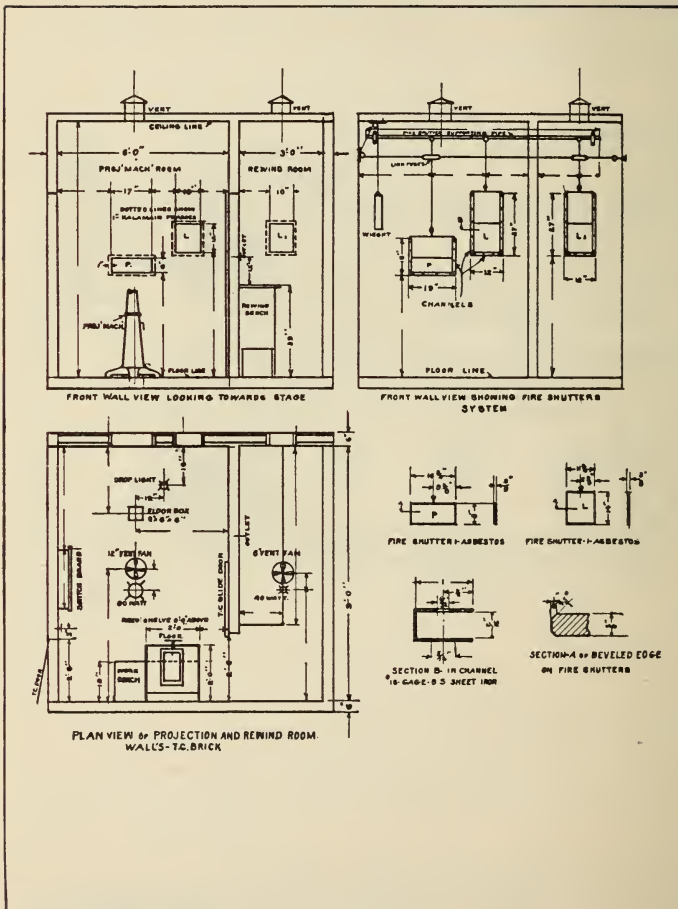

VENT
CEILING LINE
6'-0"
3'-0"
PROJ' MACH' ROOM
REWIND ROOM
REWIND BENCH
PROJ' MACH
FLOOR LINE
FRONT WALL VIEW LOOKING TOWARDS STAGE
WEIGHT
CHANNELS
FLOOR LINE
FRONT WALL VIEW SHOWING FIRE SHUTTERS SYSTEM
DROP LIGHT
FLOOR BOX
12" VENT FAN
6" VENT FAN
SWITCH BOARD
T.C. SLIDE DOOR
OUTLET
WORK BENCH
PLAN VIEW OF PROJECTION AND REWIND ROOM.
WALLS - T.C. BRICK
FIRE SHUTTER - ASBESTOS
FIRE SHUTTER - ASBESTOS
SECTION B - IN CHANNEL
18-GAGE-B S SHEET IRON
SECTION-A OF BEVELED EDGE
ON FIRE SHUTTERS

FIG. 51

THE PROJECTION ROOM

The room should contain everything necessary for perfect projection, but nothing that can be done without. Nothing but the projection of films should be done in the room, an ante-room should be provided with work bench and re-winder. The room should be large enough to permit the free movements of the operator or operators and should contain the necessary closets and shelves for the operators' clothes, tools, supplies, etc.

The operator should see that he has sufficient supplies, such as fuses, lugs, film cement, asbestos cable, condensers, various lubricants, carbons, mica, brushes for motor, belting and a few of the necessary parts for machine to replace those parts that are liable to need replacing owing to wear, etc.

The operator should carry a kit of tools that will permit him to do any repair work that he may be called upon to do, the manager of today has very little use for the would-be operator who shows up on the job with a ten-cent pair of pliers and a piece of string.

If using rheostats then same should be installed outside the projection room, but the control handles should be placed so that they are within easy reach of the projectionist, without his having to leave the machine. The operator will thus find working conditions a whole lot more comfortable.

All openings such as projection holes and port

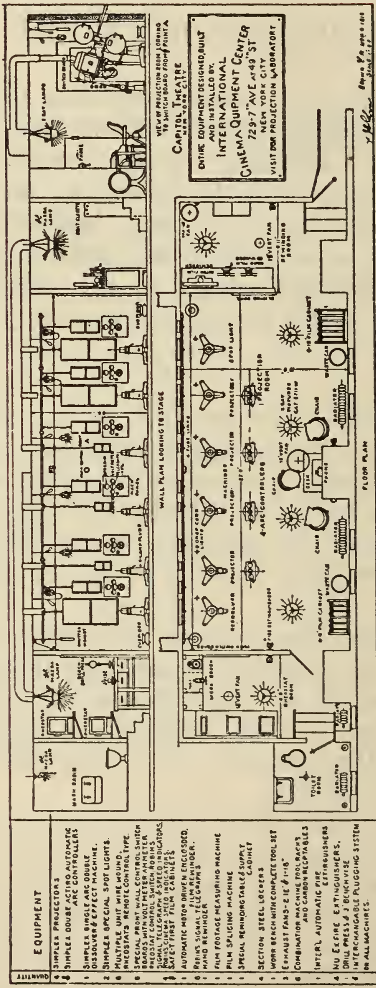


FIG. 52

PROJECTION ROOM, CAPITOL THEATRE, N. Y. C.
Showing Positions of Projectors—Rheostat Controls—Panels, Etc.

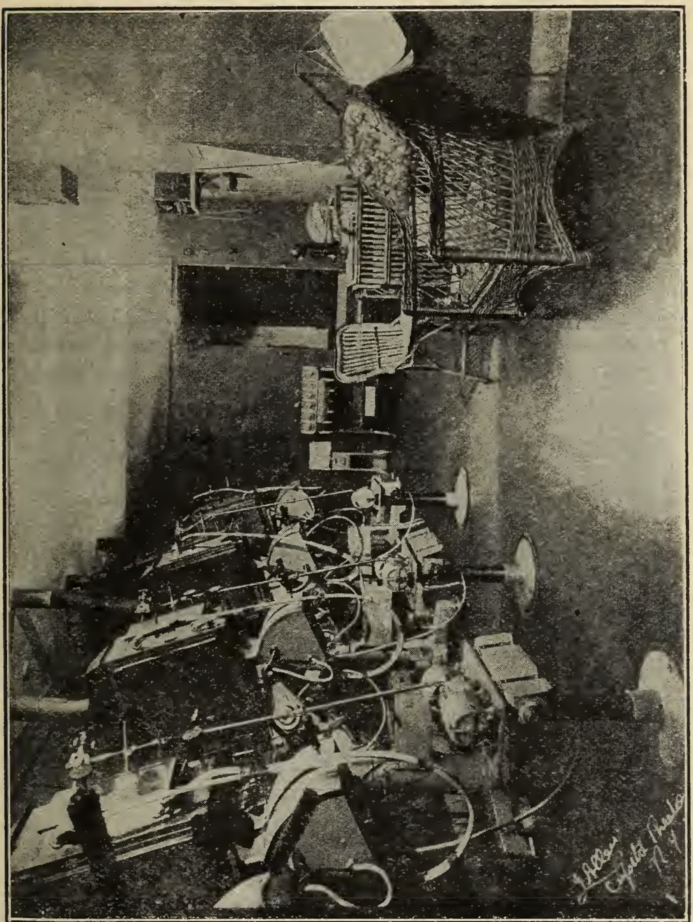


FIG. 53
Capitol Theatre, New York City

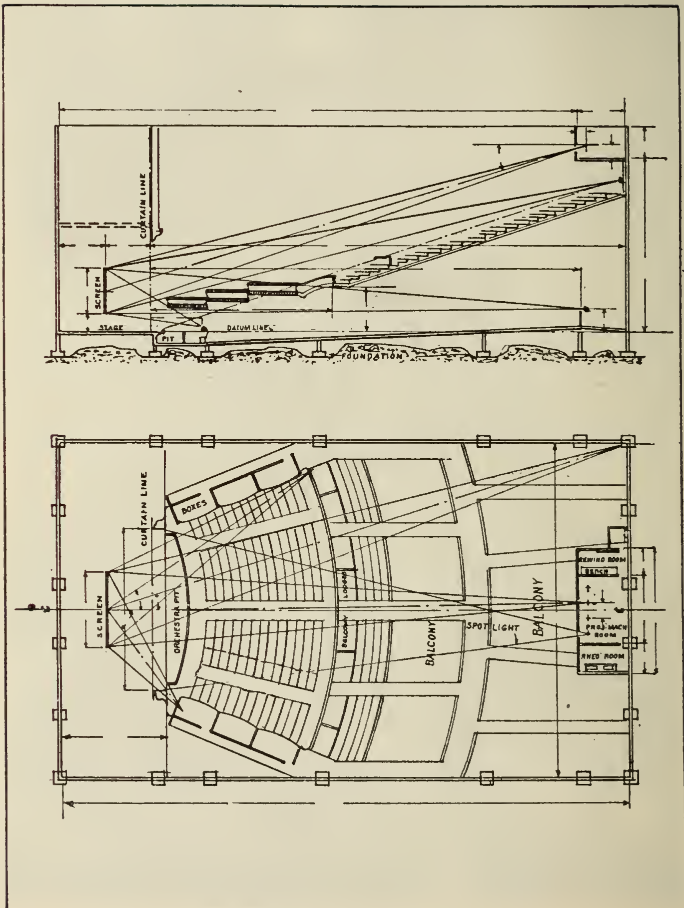

CURTAIN LINE
SCREEN
STAGE
PIT
DATUM LINE
FOUNDATION
BOXES
ORCHESTRA PIT
LOGGIA
BALCONY
SPOT LIGHT
REWIND ROOM
PROJ. MACH ROOM

FIG. 54

holes must be so equipped with shutters that they will all close automatically in case of fire.

A lot could be said about the position of booth and the construction of same, but the trouble is that the operator is generally the last man a manager or exhibitor will consult in this matter when planning the theatre, so the operator has to work under conditions as he finds them.

One thing we would advise and that is, that the walls of the booth should be painted a ~~flat black~~ GREEN (if same has not been done). The size of all openings should be reduced as much as possible, shade all lights so that none of the light finds its way into the auditorium of the theatre.

Each operator naturally has his own idea as to just what constitutes an ideal projection room, however, we are submitting in the following pages a detailed description of the furnishings and fittings of two well known and much discussed projection rooms in New York City.

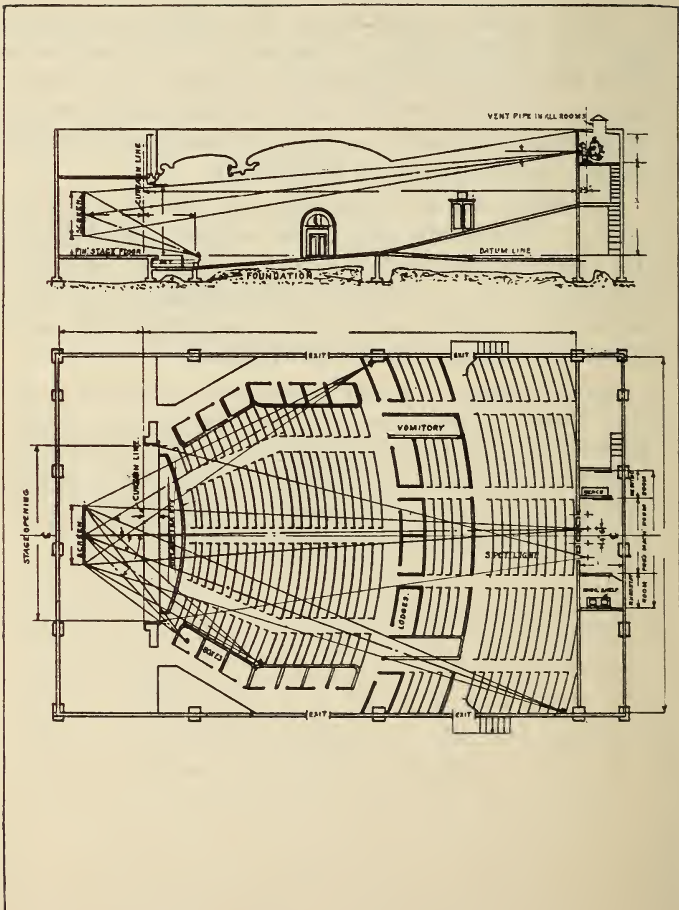

VENT PIPE IN ALL ROOMS
CURTAIN LINE
SCREEN
FIN. STAGE FLOOR
DATUM LINE
FOUNDATION
EXIT
EXIT
VOMITORY
STAGE OPENING
CURTAIN LINE
SCREEN
SPOTLIGHT
LODGES
BOXES
EXIT
EXIT

FIG. 55

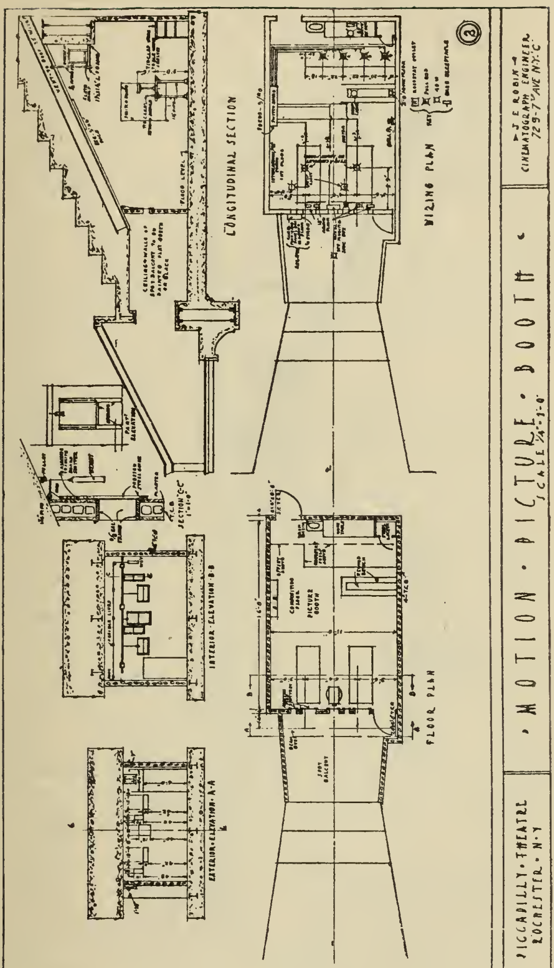

LONGITUDINAL SECTION
WIRING PLAN
FLOOR PLAN
INTERIOR·ELEVATION·B-B
EXTERIOR·ELEVATION·A-A
· MOTION · PICTURE · BOOTH ·
SCALE ¼"=1'-0"
PICCADILLY · THEATRE
ROCHESTER · N · Y
J E ROBIN
CINEMATOGRAPH ENGINEER
729-7th AVE N.Y.C

Fig. 56

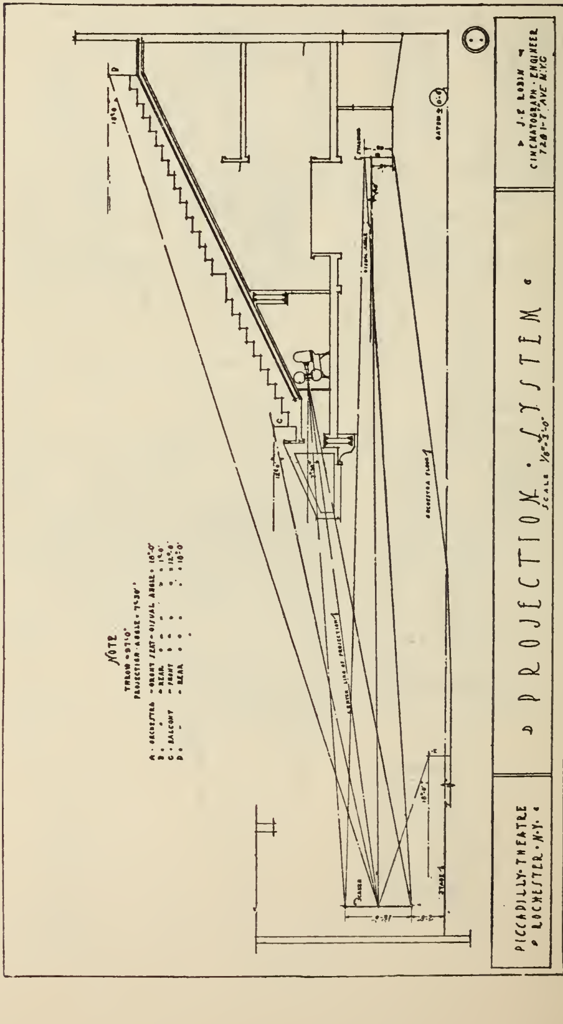

PROJECTION · SYSTEM
SCALE 1/8"=1'-0"
PICCADILLY·THEATRE
ROCHESTER·N.Y.
J.E. ROBIN
CINEMATOGRAPH·ENGINEER
NOTE

FIG. 57

AN IDEAL PROJECTION ROOM

"The largest theatre in the world," the New York Capitol, has a projection room in keeping with the rest of its luxurious appointments. The projection room proper is 41 feet long and 19 feet deep and as will be seen by the accompanying photographs, it is furnished with everything necessary for perfect projection. Four of the latest Type S Simplex machines are responsible for the projection, each machine is equipped with an automatic arc control and a metal cabinet for receiving hot carbon stubs.

There is also a special spotlight and a Simplex Stereopticon, the spotlight is fitted with an 8-inch iris diaphragm so constructed and arranged that any sized spot can be immediately obtained, it is also fitted with a curtain dissolve which allows the operator to gradually flood or dim the stage for special lighting effects, and dispenses with the troublesome masks.

Current supply is D. C. through 50-125 multiple unit rheostats. The rheostats are placed in a special room adjoining the projection room, the rheostat controls being on the front wall near each projector within easy reach of the operator. Each machine draws 125 amperes at an approximate pressure of 68 volts.

The wiring for the projectors is brought under the floor up through the machine pedestals and then to machine switch. Cool and comfortable working conditions are assured at all times, the room having 4 windows opening directly into the

street, besides two 24-foot exhaust fans; a vent pipe runs from the lamp house of each projector to the open air.

At the far end of the projection room is the rewind room, here are found a specially built film vault for the storage of film, an enclosed motor rewind equipped with an automatic stopping device in case the film should break in the course of rewinding. The comfort of the projectionists has not been overlooked. An up-to-date washroom and lavatory together with a rest room for their special use adjoins the projection room.

The throw is 197 feet and the picture is projected on one of Robins' special white screens. The projection of the pictures and the musical score are synchronized through the medium of the Robins speed indicators.

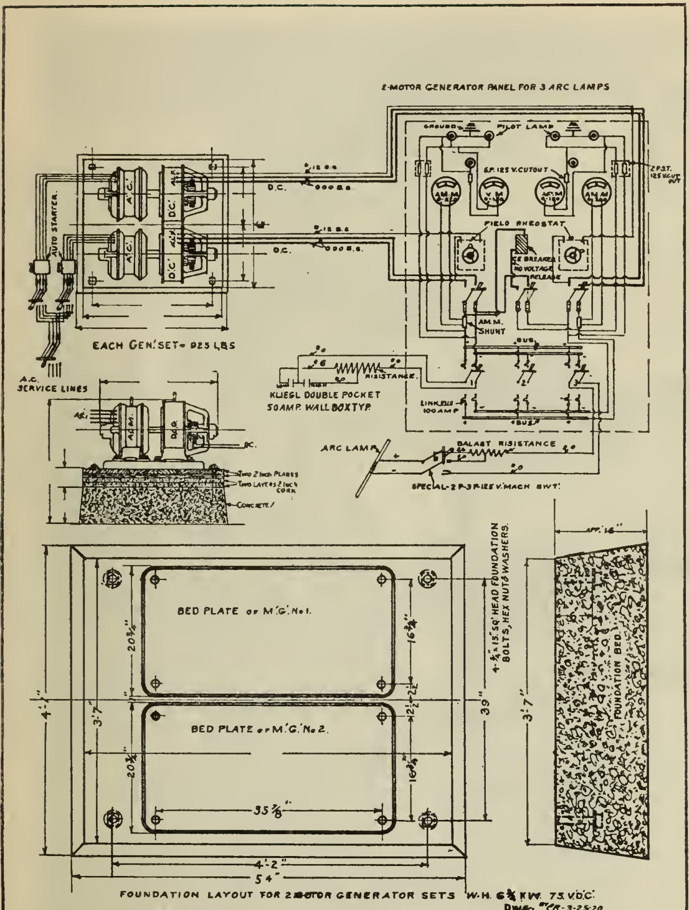

2-MOTOR GENERATOR PANEL FOR 3 ARC LAMPS
PILOT LAMP
FIELD RHEOSTAT
AM.M. SHUNT
EACH GEN. SET = 925 LBS
A.C. SERVICE LINES
AUTO STARTER
D.C.
KLIEGL DOUBLE POCKET 50 AMP. WALL BOX TYP.
ARC LAMP
BALAST RISISTANCE
CONCRETE
BED PLATE OF M.G. No. 1.
BED PLATE OF M.G. No. 2.
FOUNDATION BED
4-3/4" x 15" SQ. HEAD FOUNDATION BOLTS, HEX NUTS & WASHERS.
FOUNDATION LAYOUT FOR 2 MOTOR GENERATOR SETS W-H. 6 3/4 KW. 75 V.D.C.

FIG. 58

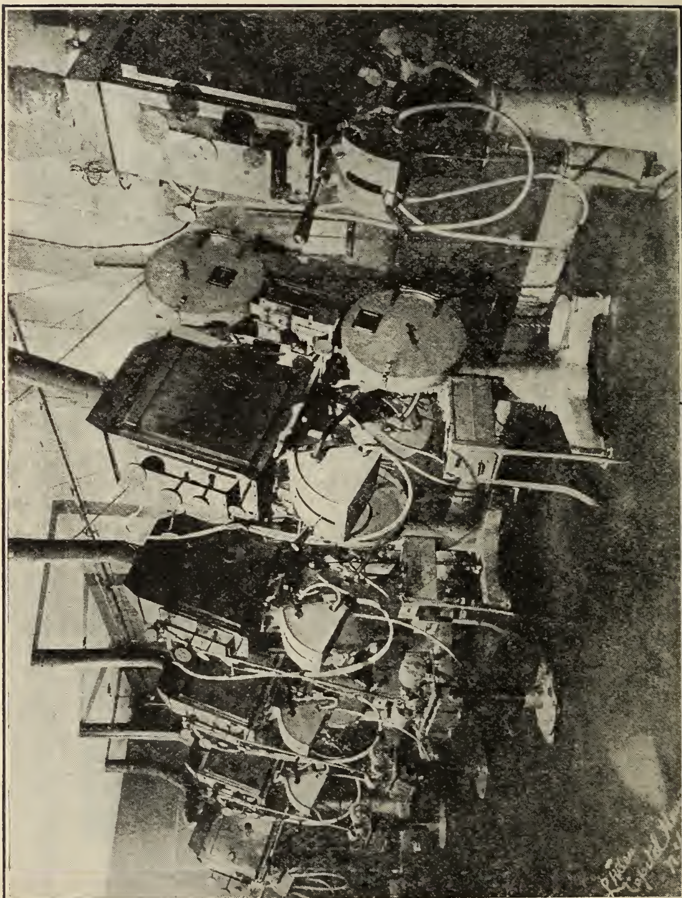


FIG. 59
Battery of Projectors, Capitol Theatre, New York City

PROJECTION ROOM INTERNATIONAL CINEMA EQUIPMENT CENTER

The projection room is 20 feet long by 10 feet deep by 11 feet in height. It is built of 6-inch hollow tile, plastered on both sides. Floor is arched reinforcement cement with 2-inch covering of red on the top, which renders the booth neat in appearance and easily kept clean.

Placed in the bottom of the booth are four 11 by 16-inch openings covered with fine mesh screen providing fresh air intake. An 18 by 24-inch vent flue leading to the outside carries away the warm air. This flue has a double opening in the booth, one which is covered by a grill, and in the other opening is placed an electric ventilating fan, which is controlled through the switchboard. By arranging the exhibits in this manner it does not impede the free passage of air.

There are eight openings in the booth. Each is protected by the International Fire Shutter System, which consists of kalomein frames built into the wall with channel iron slideways attached into which are fitted 1½-inch asbestos fire shutters. The shutters are suspended by chains with fusible links from a pipe which runs along the front wall of the booth, and is controlled by gravity when a fuse melts and releases a string, the weight turns the pipe and drops all shutters.

The fire shutter is very neat in appearance and extremely effective.

There are two indirect fixtures in the booth

which are controlled by push button placed adjacent to the entrance of the booth. About 12 inches from the front wall of the booth, and directly in front of each machine, is a drop light with a Crescent lamp guard and porcelain socket. The lighting of the booth is all on direct current.

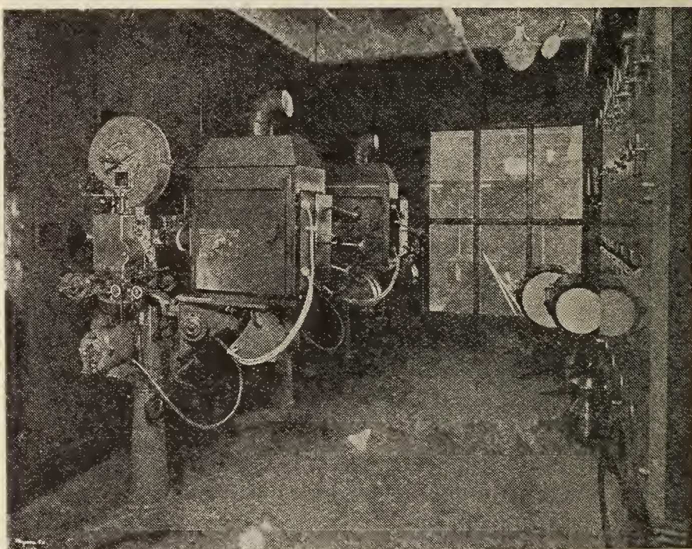


Fig. 60

There is a signal telegraph controlled from the review desk in the interior of the theatre and a return call system; also an extension Bell telephone connecting with the main switchboard of the International Cinema Quipment Centre. For the storage of film during the course of projection

the two 15-inch 5-section Safe-T-First cabinets are used.

Directly in the rear of the booth is a large kalomein bench 6 feet long by 18 feet wide, which is used as a rewinding table, and the lower por-

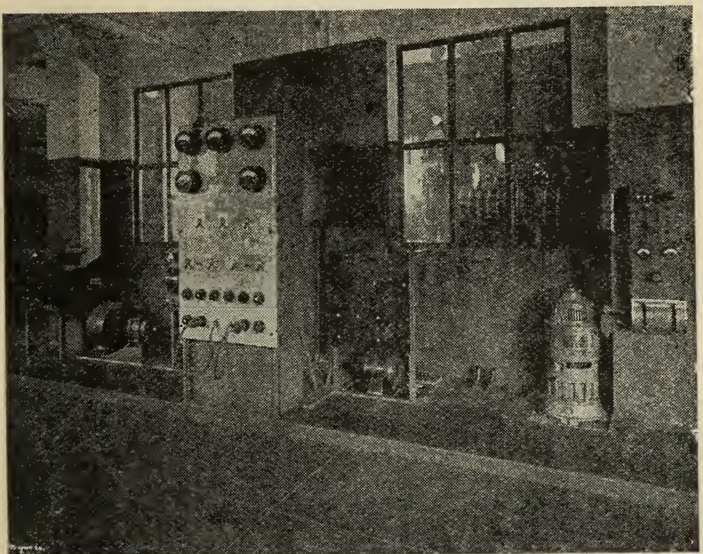


FIG. 61

tion, which is divided into drawers, is used for accessories and supplies.

There is also provided an automatic sprinkler system in the booth, fire extinguishers and pails.

The electric service consists of 110/220 volt Edison D. C., 110/220 volt single phase 60 cycle A. C. and 220 volt two phase A. C. This power is supplied direct from the lighting company on

a special service run from the basement. Directly behind the machines in the rear wall of the operating room is a special control board designed by J. E. Robin. This board is 6 feet square of a dead face type. All meters and switches operate from the front and are back connected. The board is built of blue Vermont marble 2 inches in thickness.

Fig. 62 shows the appearance of the front and

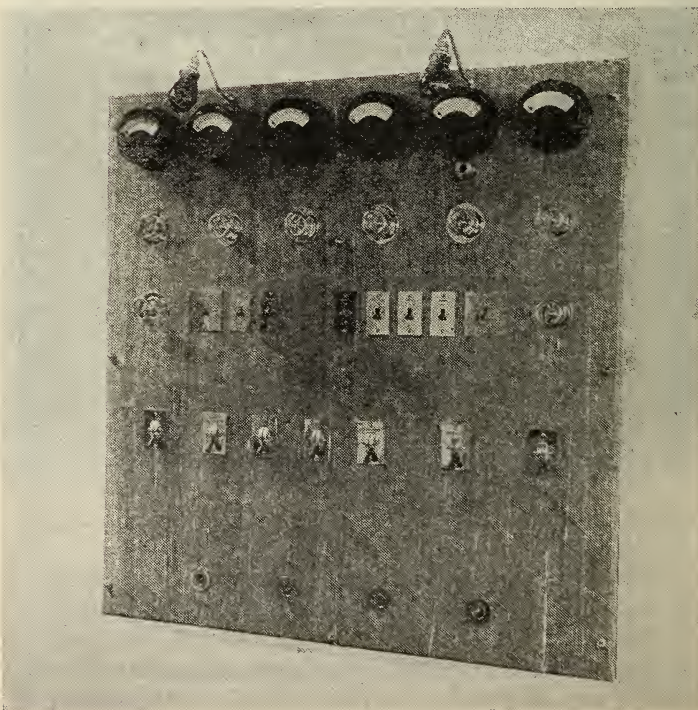


Fig. 62

Fig. 63 the rear. On the face of the board are mounted two Weston D. C. ammeters, two Weston A. C. ammeters and one Weston D. C. and one Weston A. C. volt meters. The six hand wheels directly underneath the meters control volt and ammeter switches, rendering it possible to read the amperage or voltage on either side of the line, or the arc, and on any control device being tested. Each D. C. ammeter is provided with five interchangeable shunts, and each A. C. ammeter with three current transformers, which are shown to the left of the photograph Fig. 63. The A. C. ammeter has a push button underneath in the circuit which is connected with a multiplier to permit reading on the low voltage of transformer. The two other hand wheels shown on the left are on the right side of the booth control field rheostat, and the upper row of switches machine motor circuits and lighting, vent fans and Mazda lamp A. C. transformers. The lower row are the four main line switches—two provided for the generator switchboard and two for the engines.

As shown on photograph Fig. 63—12-200 ampere Kleigl plugging pockets. These are underneath the front of the board and underneath the booth directly from each projecting machine is run in conduit, concealed in the floor two No. 0 wires, which come out through a furrel in the bottom of the board, of which there are four, and terminate in five-foot long generator cable with a Kleigl plug attached.

Directly underneath the projecting machine in the booth is a ventilator, where are located A. C. arc transformers, A. C. Mazda transformer, D. C. and A. C. rheostat and D. C. Mazda lamp

rheostat. All connections from these devices run direct from the main switchboard and terminate in the box of main switchboard. It is possible, therefore, by plugging in one of the four machines into the pockets to operate on the different kinds of apparatus either A. C. or D. C., running one or four machines simultaneously.

All wiring of conduits are concealed in the floor and walls of the booth, and wires leading to the machines, meters and arc switch come up directly

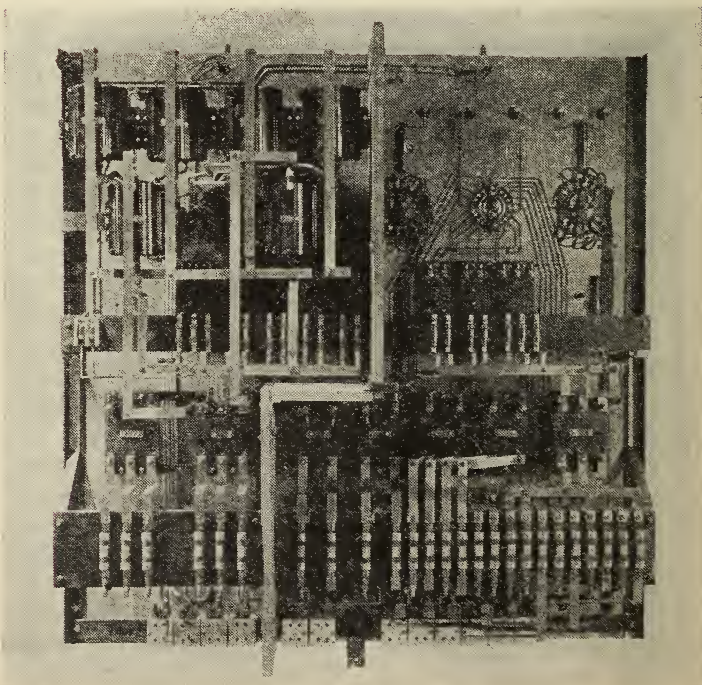


FIG. 63

in the centre of pedestal. Set flush in the wall directly underneath the lookout hole in front of each projector is a special control panel board of blue Vermont marble with a volt meter and ammeter mounted on the face of the same, and Robin Cinema electric speed indicator. There is also provided a radial rheostat switch connected to the multiple unit rheostat. This switch is used to control the amperage at the arc which may be run from 5 to 100 amperes. This marble cover on panel board is arranged with hinges to open down into the booth, thus rendering it accessible.

In addition to the general booth equipment there is shown to the rear of the booth in photograph the motor generator testing department. In this space are five different types of motor generators, both single and two phase, with special panel board in front of each one with control switches and instruments.

Each generator is mounted on an iron pan, which is attached to frame and rests on cork and rubber to prevent noise when in operation. The top of the platform is covered with a battleship linoleum bound with brass. The switchboard shown in the centre controls the motor generator sets, and is interconnected with the main switchboard in the booth. This board is also dead type with the front of the blue Vermont marble of 2-inch thickness, with all switches back connected and enclosed with a steel cabinet with two doors making it accessible from the rear. On the upper row are instruments consisting of two two-phase Weston indicating watt meters, one Weston single indicating watt meter. This serves to show the wattage used in running the various machines.

The two lower machines are without meters, which are connected across the two, coming out of the bottom of the board, which indicate in watts the power being taken in any of the generators. In this manner the current being used can easily be determined. The voltage and amperage may be obtained from the meters on the individual panel or from the interior of the instruments in the booth.

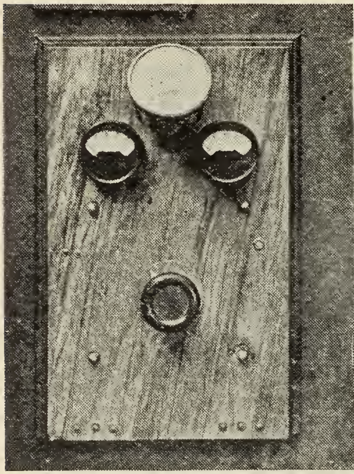


FIG. 65

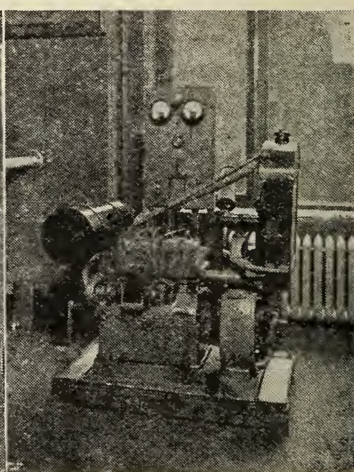


FIG. 66

There are 10 plugging pockets on the board, two being connected with each machine. The two cables shown coming out of the board connect with the main switchboard in the booth. It is possible, therefore, to plug one or two arcs on any of the generators or for comparative test to run two generators simultaneously with one arc on each.

This switchboard contains both current transformers, voltmeter multipliers and resistances and other necessary switches, cutouts and accessories.

The machines consist of two Type "S" Simplex —one Simplex Mazda equipment with A. C. and D. C. regulator and one Simplex with 1½ to 1 shutter—5 to 1 movement and Argus sheck adapter. This machine is also equipped with Feaster non-rewind. All projectors are enameled battleship gray with fittings in nickel. Each machine is equipped with volt and ampere meters on front panel, also Robin Cinema electric speed indicators, lamp house with Simplex arc periscope, which throws the image of the arc on the walls or ceiling. The Mazda lamp, A. C. transformers and D. C. rheostats are located in the floor of the booth, and are controlled from the interior by hand wheels somewhat similar to those used in the pilot house aboard ship.

CARBONS

There are two classes of carbons generally used in arc lamps, solid and cored; they are composed of coke, tar, or the graphite deposited in the inside of retorts used for manufacturing illuminating gas. With solid carbons the crater travels around the ends of the carbons, the current always tending to take the path of least resistance; with *cored* carbons, which are solid except for an inner core of softer carbon, the travel of the crater is reduced and the distribution of light more steady. The effect of the core is to confine the current to the center of the rod, and consequently the arc, due to the core having a higher conductivity than the surrounding material. With cored carbons the voltage across the arc is reduced.

In an alternating current arc the crater alternates from one carbon to the other with each reversal of current, so that both carbons are consumed equally when the rods are horizontal. When vertical, the upper carbon will be consumed about 8 per cent. faster, owing to the action of the ascending currents of heated air.

THE PROJECTION ARC

Since the experience of some operators has been limited to projection with the alternating-current arc, the following suggestions are offered on projection with the direct-current arc:

The direct-current arc should be approximately 5/16 to ⅜ inch long or about twice the length of the alternating-current arc. Too short an arc

will not give a satisfactory light, the trouble being not in the machine but in the carbon setting.

Use only the best projection carbons. Projection carbons vary greatly in quality and good re-

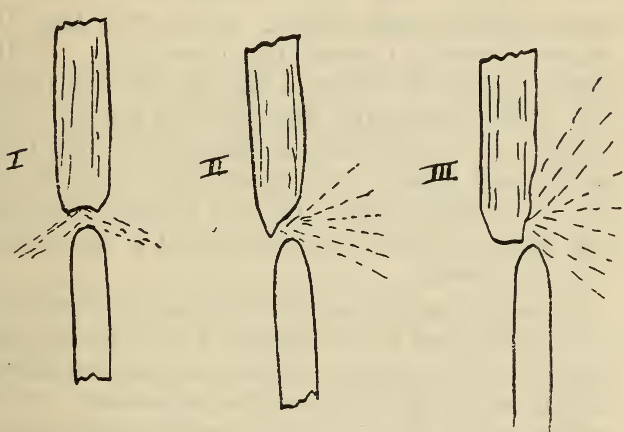


FIG. 67

Right and wrong way to set D. C. arc. I. Lower carbon not far enough forward. II. Correct setting. III. Lower carbon too far advanced

sults cannot be obtained from poor carbons. Inferior carbons are particularly liable to give trouble on arc currents of 50 amperes and above. Good carbons will be uniform in diameter, straight, free from cracks running around the circumference, and uniform in density throughout. The core will be true to the center of the carbon and will not drop out while burning. A hard spot in the carbons will cause the arc to jump and sputter, while a soft spot will cause it to flame or needle and burn away very rapidly. The main point in setting the carbons is to get a crater to

form good size and facing the center of the condenser lens as nearly as possible.

Take care to have the carbons in perfect alignment sidewise and a long enough arc that the lower carbon does not "mushroom." Pull the upper carbon back slightly which will face the crater forward toward the condenser. If the upper carbon is not back far enough the crater will point downward and not toward the condenser. If too far back, a long "skirt" will form on the back edge of the upper carbon which will give an unsteady light and may break off in feeding, giving a very poor light until a new crater can be formed.

Do not try to decide upon the merits of carbons by burning just one carbon of a kind in just one way; try out a carbon setting at least one whole day to see if results cannot be improved.

There has come into use recently a small diameter metal coated hard core negative carbon which has been found in many cases to improve the operation of the arc by holding it quiet and steady.

CARBON COMBINATIONS FOR NATIONAL CARBONS

DIRECT CURRENT

Current	*Size Carbons*
For 25 to 50 Amps. D. C. use	5/8 x12 inch Cored Upper 5/16x6 inch Metal Coated Solid Lower
For 50 to 65 Amps. D. C. use	3/4 x12 inch Cored Upper 11/32x6 inch Metal Coated Solid Lower
For 65 to 70 Amps. D. C. use	7/8 x12 inch Cored Upper 11/32x6 inch Metal Coated Solid Lower
For 70 to 85 Amps. D. C. use	7/8 x12 inch Cored Upper 3/8 x6 inch Metal Coated Solid Lower
For 85 to 100 Amps. D. C. use	1x12 inch Cored Upper 7/16x6 inch Metal Coated Cored Lower

ALTERNATING CURRENT

Amperes	*Carbon Diameter*
40 or less than 60	5/8 inch Combination
60 or less than 75	3/4 inch Combination
75 or less than 100	7/8 inch Combination

PROJECTOR CARBON MANUFACTURING PROCESS

In the manufacture of high-grade projector carbons it is necessary to use an especially prepared carbon flour. The flour is carefully mixed with the necessary binding material and forced by hydraulic presses under high pressure into the desired shape. If a cored carbon is wanted, a steel needle is suspended in the center of the die. The forced carbons are then placed on racks to cool and when sufficiently cool they are cut in the proper length for baking. To insure absolute straightness, correct size and perfect stock before baking, the cooled carbons are thoroughly inspected before being turned over to the baking department.

In the furnaces, the carbons are subjected to the temperature necessary to produce a uniform carbon of certain definite prescribed qualities. After the bake is completed, the furnace is sampled and the carbons examined by the testing department before being sent along for finishing. These tests are even more severe than those to which a projector carbon is subjected by the user.

Upon receiving the testing department's O.K., the carbons are sorted for straightness and examined for imperfections, and if they are hollow shells, made ready for coring. Every precaution is taken in the coring department, where the hollow shells are filled to see that the core

material fills the entire length of the carbon. The composition of the coring material is of considerable importance as it determines largely the burning quality and color of the arc. After coring, the carbons are dried, finished, pointed, inspected and placed in the shipping stock.

THE CARBON ARC

In the direct current arc, the crater of the positive carbon forms the principal light source. The positive crater is of relatively large area, while the negative spot is small and is not usually considered as a light source. While 95% of the light emitted by the arc comes from the positive crater, the characteristics of the negative carbon are of vital importance in securing steadiness of operation. In operation, the positive crater is set so as to face the axis of the optical system. In setting the carbons in this position, care must be taken to reduce to a minimum the shading of the crater by the negative carbon. In this respect, the direct current arc is superior to the alternating current arc. A direct current arc is longer and therefore gives less shading of the crater. The greatest advantage of the direct current arc is the fact that the current travels only in one direction and therefore the positive crater receives electrical energy continuously and consequently maintains a higher temperature.

As was stated above the characteristics of the lower carbon on direct current are of greatest importance in securing steadiness of operation. The size of the upper carbon is determined by the power imputed to the arc. If the positive is too small the current will overlap the end of the

carbon and the arc will be noisy and unsteady. If too large, the crater covers the end of the carbon and the arc again will be unsteady, because the average temperature at the tip is lower. With the negative carbon, the carrying capacity is the important factor since the size of the negative carbon required by the negative spot is small.

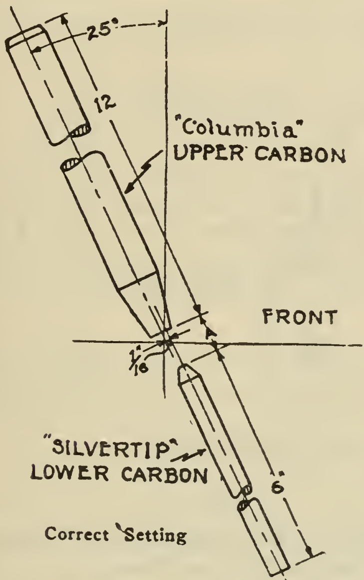


Fig. 68

A small carbon keeps the arc steady and also eliminates the shadow due to the shading of the crater by the negative carbon itself. This problem has been solved by plating the solid negative over its entire length with a series of metallic coats forming a shell of metal of low electrical

resistance around the carbon. This metallic coating volatizes in the heat of the arc and thus prevents the spattering of the rear condenser lens with the heavy metal beads formed with the old style metal coat. The coating carries the major part of the current and makes possible the use of

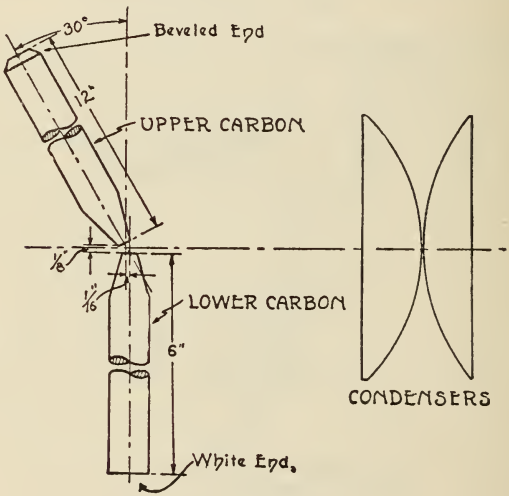


FIG. 69

a small negative with the high currents required by long throws and dense films.

The direct current arc is inherently stable and the range of arc voltage can be made whatever the projectionists desire, but there is one fact to be borne in mind that, for each given current value there is a definite arc voltage at which the arc operates at maximum efficiency. With a constant current value, gradually shortening the arc length, will finally produce an unstable arc; just

previous to that point is the limiting voltage for the current chosen. Or, otherwise, a given current requires a certain arc length of voltage. To increase the current and not change the arc length, is equivalent to shortening the arc in the first case and the arc becomes noisy. For this reason increasing voltages are required for increasing currents.

When using small diameter solid metal coated negatives on direct current we start at 52 volts for 30 amperes and increasing by 2 volts for each increase of 10 amperes, reaching 62 for the arc voltage at 100 amperes, a saving of 0.7 kw. or 10 per cent. in arc wattage, than in case where the old style large diameter cored negatives are used, starting at 55 arc volts for 30 amperes direct current, and increasing voltage and current in same proportion as recommended in former case.

In the past when using cored negative carbons the basis for choice of the negative was a ratio of 1 for the negative diameter, to 1.65 for the positive diameter, or a cross-sectional ratio of 1.2.

Under the table of Carbon Combinations for direct current projection, the new developed solid small diameter metal coated negative calls for a cross-sectional ratio of 1.4, the negative having ¼ area of the positive.

What determines the size of a carbon for given service is the ability to stand up under it but the limiting factor differs in A. C. and in D. C.

On direct current the limiting factor is the crater. Since the temperature of a carbon arc is constant just as is the temperature of boiling water—be there a teaspoonful or a barrel full—

so, by putting into the carbon more current, we merely increase the number of the hot, light-giving areas until finally the tip of the carbon or crater can no longer accommodate an increase and then no further increase of light is possible for that carbon. The body of the carbon is as yet unaffected by the current but the crater can no longer take care of further increases. This is the limiting factor and so we take the next larger sizes.

On alternating current the crater is but half the size of the crater formation on direct current, owing to the fact that the energy is divided equally between the upper and lower carbon; therefore, we can go still higher in current density on A. C. without reaching a crater limit but we now find that the carbon body cannot carry an unlimited amount of current without glowing and oxidizing away sharply, so we are limited on A. C. to the physical characteristics of the carbon. Using the old style alternating current carbon, a short air gap gives a hissing and sputtering arc which is very unstable. By using cored carbons, the cores of which are impregnated with carefully prepared chemicals, an absolutely silent and steady alternating current arc can be obtained. By using the proper chemicals a light source of high intensity is obtained which is far above that of the old cored carbons.

This change in the construction of carbons for use with alternating current projection is one that has come to the front in the last year and has met with marvelous success. It has brought the alternating current arc in close competition with the direct current arc and it has allowed

many houses who had seriously considered adopting other sources of illumination to continue with the alternating current arc without necessitating a single change in or about the lamp house or in

FIG. 70

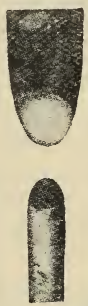


FIG. 71

the wiring. The mere substitution of these new carbons for the old style alternating current carbons makes the alternating current arc a very desirable and economical light source for projection.

In addition to fulfilling the general requirements, the carbon arc has other characteristics which make it adaptable for motion-picture work. These characteristics are: Color of light; Reliability; Flexibility; Steadiness.

Color of Light: Until recently, the color of the light used for the projection of the high-class film was a source of much annoyance. It is obvious that where the picture is taken in the open and in bright daylight, the effect upon the screen would

be inferior unless the projection light source approached that of daylight in color value. The light of the direct current arc is the nearest approach in color value to daylight of any of the known illuminants that could be used for motion-picture projection. The light is a pure white of high intensity. The light of the alternating current arc using the modern high-grade projector

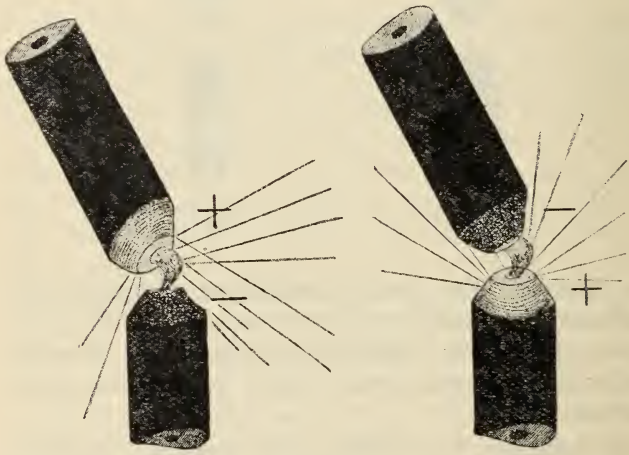


Fig. 72
Showing Effect of Arc Being Connected Upside Down

carbon approaches that of the direct current arc both in color value and intensity. A pure white light is beyond doubt the proper kind of light to use for projection since it brings out the high lights and shadows and will project upon the screen a picture that will please the most critical audience.

Reliability: The arc in the hands of an efficient projectionist, is a very reliable light source. It is not easily affected by fluctuations in line voltage and therefore will give an even screen illumination where other illuminants will fail. Carbons have a definite length of life and therefore the projectionist can guard against the failure of light in the middle of a reel of film.

Flexibility: The carbon arc gives a steady, flexible light, variable at the will of the operator according to the density of the film. No two films are alike and no two parts of the same film are of the same density and consequently to give a true artistic presentation of any picture you must have a flexible light source.

Steadiness: Both the direct and alternating current arcs are giving absolutely steady illumination. The traveling of the arc and negative shadows have been eliminated in arc projection.

In conclusion, emphasis should be placed upon the use of proper carbon combinations. The carbon manufacturer specifies a definite diameter of carbon for a definite current requirement and any deviation from this will result in poor projection. If the projectionist is without positive knowledge of the amount of power he is using he can obtain this by means of a voltmeter and ammeter. Standard instruments for this purpose can generally be obtained from the local power plants.

THE ELECTRIC ARC

When a current, under a pressure, is passed through two carbon rods, with their ends first in contact and afterward gradually separated a short distance, a brilliant arc of flame called the *electric arc,* is established between them. This arc is composed of carbon vapor, that is, the high temperature caused by the passage of the current through the resistance of the contact surfaces causes the carbon to practically boil and the vapor thus arising, being a much better conductor than the air, conducts the current across the gap from one carbon tip to the other. This volatilization occurs chiefly at the end of the positive carbon terminal where the current enters the arc, and this point is also the seat of the highest temperature and maximum light-emitting power. As the arc is maintained across the gap, disintegration of the carbon takes place, the carbons waste away, and a cup-shaped depression, termed the *crater,* is formed in the *positive carbon,* while the tip of the negative carbon has a conical form. The negative carbon being at a lower temperature than the positive, the vapor of the boiling carbon condenses upon its surface as pure graphite. Both carbons waste away, but the consumption of the positive carbon is about twice as rapid as that of the negative, since it is this carbon from which most of the vapor comes and part of which is re-deposited as graphite on the negative cone-tipped carbon.

The light emitted by any heated body increases with its temperature. The temperature of the

carbon in the crater, when in a state of ebullition, is about 3500° C., this being the hottest portion of the arc, and consequently the point from which the most light is emitted. About 12 per cent of the energy supplied to an electric arc appears as light, the balance being represented by the heat evolved. About 85 per cent of the light emitted from an arc lamp is reflected from the crater, the maximum illumination being in a zone surrounding the lamp at an angle of about 40° to the horizontal.

When the arc is "struck" by bringing the carbon electrodes together, and then, separating them for a short distance, the arc possesses peculiar characteristics depending upon the length of the gap between the ends of the carbons. When this distance is too small the arc emits a peculiar hissing noise, and is called a *hissing arc*. It is caused by a too rapid volatilization of the carbon, due to the excessive current that would flow through the lamp with a short gap between the carbons. *Spluttering sounds* produced by the arc are due to impurities in the carbon, or loose-grained carbons. By adjusting the distance between the carbons, a point will be found where the arc burns quietly and steady, and is then termed a normal or silent arc; if this distance be exceeded the arc flames. Impure carbons, or carbons not properly baked, will produce a flaming arc, which is accompanied by a loss of light and rapid increase in carbon consumption.

In the early days of the motion picture industry, the source of light was, in many instances, of the well known calcium type. Artificial gas, such as acetylene was also used, but as the public became

interested in this new form of entertainment and education, the demand for a better form of illuminant necessitated discarding these sources of light. This was due to the increased size of the picture theatres and the demand for larger and better illuminated or more distinct pictures. It was for these reasons, primarily, that the electric arc was adopted for motion picture work.

The electric arc is particularly well adapted to this service as it is one of the most intensely brilliant artificial illuminants known to science. The major portion of the light produced, however, is not obtained directly from the arc, but from the incandescent tips of the carbon electrodes. The brilliant illumination of the film is secured by the condenser lenses which collect a portion of the light produced and converge it through the aperture plate, the illuminated area being generally known as the "spot." It is obvious, therefore, that if the spot is to be uniformly bright over its entire area the source of light must be concentrated in a fixed and as small a point as possible.

1. (a) The earliest current supply used for an electric arc for a light source for projection work was alternating, due to the fact that alternating current is more widely distributed and therefore, more readily available, and also because control apparatus for alternating current was simpler, more easily designed and less expensive. It is practically impossible to find direct current mains everywhere, except in the centers of some of the large cities, while alternating current is available at practically all places where there is a sufficient number of people to warrant the establishment of motion picture houses. The apparatus for the

control of alternating current for an alternating current arc is simple, comparatively inexpensive, and on the market in a variety of forms readily available for practically any current throughout the range of application. The advantage of alternating current from a carbon standpoint lies only in the efficiency of the supply to the arc. By means of a transformer, reactance, etc., the line voltage can be very readily reduced to any value required by the arc with very little loss of power.

1. (b) That the arc produced by alternating current is not so satisfactory as the arc produced by direct current is quite generally recognized. This fact is due to a number of physical characteristics of the alternating current arc. (1) Both electrodes are heated almost uniformly, producing practically equal illumination. However, only the incandescent tip of one carbon can be located at the proper focal point for the condenser lenses. (2) The average temperature of the crater is comparatively low on account of the rapid transfer of this crater from one carbon end to the other. (3) If an improper revolving shutter is employed or if a satisfactory shutter is operated at other than correct speed, the pictures will have an undesirable flicker, due to the fact that the value of the alternating current is zero twice each cycle of 120 times for a 60 cycle circuit. (4) The alternating current arc has a greater tendency to travel around the ends of the electrodes, which constantly shifts the incandescent area of the carbon tips, thus producing "ghosts" on the screen. (5) The light produced by alternating current has a preponderance of the violet end of the light spectrum, which is not so desirable as

the yellow, from an optical point of view. (6) The cost of power for the alternating current arc is high, because the current required to produce a given illumination is about three times greater than the direct current required. From a carbon point, the disadvantage is chiefly in operation. The very highest grade, and therefore costly, carbons are required. The very short arc required for satisfactory operation means constant attention on the part of the operator. Further, the high currents necessary to get the degree of illumination now considered desirable, renders such an arc very noisy, which in itself is a hardship on the operator.

2. (a) The advantages of the direct current arc can be briefly stated as being converses of the disadvantages which have been cited for the alternating current arc. Careful experiments have demonstrated that the light resulting from a direct current arc is produced by the crater on the positive carbon, by the incandescent tip of the negative carbon, and by the arc stream proper, in the proportions of 85 per cent., 10 per cent. and 5 per cent., respectively. The crater is of comparatively small area and can therefore be located at the proper focal point of the condenser lenses. This explains the fundamental advantages of the direct current arc. The ease of operation, requiring little attention from the operator and the inherent stability and good operation of the direct current arc over wide range of arc voltages, makes this form of current ideal. Very high arc wattages can be made use of on direct current to obtain the illumination essential for very large pictures, but which would hardly be feasible to attempt

with alternating current, so that in the field of projection in the large picture houses, direct current is supreme.

2. (b) The disadvantage of using direct current is primarily in the cost of converting appliances to change from alternating current to direct current, or if operating directly from 110 volts direct current, the entire line voltage enters into the cost consideration, since whatever energy is not used in the arc must be dissipated in resistance.

3. (a) If an alternating current supply system only is available and direct current is desired for the projecting machines, it is necessary to install equipment which will rectify or convert the alternating current to direct current. There are numerous types of equipment available for this service, such as Mercury Arc Rectifier, Motor Generator Sets (of which there are two classes, namely, constant potential and constant current), Rotary Converters and Mechanical Rectifiers. When any one of the various types of converting equipments is used, with the exception of the Mercury Arc Rectifier, it is advisable to provide for "break down" service, so that if the auxiliary equipment is disabled, the projectors may be operated temporarily with alternating current.

4. When alternating current only is available, and is to be used, the apparatus for obtaining the proper arc voltage may consist of a choke coil, reactance, transformer or rheostat. The transformers ordinarily used are of the single winding or auto type designed with sufficient reactance to stabilize the arc. A standard double winding

transformer having suitable voltage characteristics could be used, providing a suitable reactance coil is connected in series with the arc. Rheostats should not be considered on account of their extremely low efficiency.

5. On Alternating Current a very short arc must be maintained; we cannot deviate from this operating condition. The arc voltage is, therefore, settled for the operator and usually is between 33 and 39 arc volts; that is, at a very short arc just after feeding, the voltage may be 33 and as the arc length increased with the burning of the carbon, the arc voltage will increase to a value of about 39 volts, if the arc is permitted to get any longer we find an immediate irregularity and unsteadiness in the arc. It will be found in practice that an Alternating Current will require feeding every 75 seconds. On Direct Current we have an inherently steady arc; that is, inherently steady as compared with an Alternating Current. The range of arc length and arc voltage can be made whatever the operator desires within certain limits, but there is one fact to be borne in mind, and that is, that for each given current value there is a definite arc length and arc voltage at which we have the most efficient operation. This can be determined in the following manner: Set the Carbons for a constant current, then shorten the arc length gradually and you will finally produce an unstable, noisy arc. Just previous to that point is the minimum limiting arc length for that given current and given carbons. Likewise, take a given arc length and increase the current until a noisy and unstable arc forms, then decrease the current a trifle and you will have the condition

of maximum efficiency for that arc length. Because of the fact that a given arc length can only accommodate a certain maximum amount of current, it can readily be seen that we must increase the arc length each time we increase the current. Arc length is of course synonymous with arc voltage, so wherever we have mentioned increasing arc length we can say increasing arc voltage. So making this change in nomenclature we can make the statement that increasing current values in an arc requires an increased arc length and voltage. In actual practice it is found that there is some variation in the arc voltage for a given current with the make of the carbons and the combinations used, so that the voltages which we have listed are averages which are built up on the principles given above.

For direct current combinations using the ordinary positive carbons as indicated in the table and matching them up with plain negatives "Group A" we have a table of voltages as indicated in the following table marked "Group A" Negative Voltages:

	Group A Negatives	Group B Negatives
Amps.	Arc Voltage	Voltage
30	52	52
40	55	54
50	58	56
60	61	58
70	64	60
80	67	62
90	68	64
100	69	66

In the above table, the table of voltages given for the combinations in which the positives are

matched up with small negatives of "Group B" it will be noticed that these voltages are somewhat less. It has been found in actual practice that a well shaped crater can be obtained at these lower voltages with negative carbons of diameters which are one-half that of the positive. The usual size negative is approximately two-thirds the diameter of the positive. These special small negatives are metal clad in order to give them carrying capacity and life since they are operated at current densities far beyond their possibilities were they not metal clad.

6. The electric arc when operating on Alternating Current is known to possess the peculiarity of varying in intensity to a marked degree with the peak and zero points of the alternations; being clearly visible to the eye on frequencies under 40 Cycles.

At commercial frequencies higher than 40 Cycles, this may be visibly demonstrated by moving under the arc a light colored pencil, or other object, against a dark background. When moved rapidly under direct sunlight or direct current arc, the pencil would naturally appear blurred, owing to the rapid change of position. Under the alternating current arc, the rapidly moving pencil would seem to be a number of pencils, each one clearly visible, with dark intermediate spaces. This is precisely the same effect as is obtained by moving the pencil in the light beam of a projector with the shutter revolving.

In reality, we are therefore dealing with two intermittent periods in the light source, when operating a film projector with an alternating current arc; namely, the light interruption of the

shutter and the rise and fall of the light intensity of the arc. The former depends for its frequency upon the speed of rotation of the shutter and the number of wings therein; while the latter depends upon the frequency of the current.

In determining the relation between current frequency and shutter movement, we might for example imagine a shutter with three 60-degree openings and revolving at 40 revolutions per second.

This would give us 120 dark spots per second. An arc lamp on 60 cycle current would also have 120 dark spots per second. It is therefore evident that under these conditions, if the shutter opening occurred at the same instant at the zero point of the cycle, practically no light would be obtainable on the screen; as the shutter wings would block out the light each time it occurred.

If now the shutter be moved 60 degrees on its shaft, the maximum light would be obtained, as then the shutter openings would register with the peaks of the current alternations. These conditions, of course, would prevail only if the shutter and current were perfectly synchronized. If the speed of the shutter were reduced to 20 revolutions per second, 4 peaks at each opening.

While the 60 cycle current prevails in practice the aforementioned speed and shutter openings do not; consequently, at the normal shutter speed of 16 revolutions per second, the shutter openings would be out of step with the current frequency, with the result that some of the shutter openings would receive one, some two and some three impulses of light, causing a visible variation of light on the screen.

Since each projected image is illuminated for a time period equal to the sum of all the shutter openings during one revolution, the light impinged on each image would be the same if the light source were constant. With the alternating current arc, the light would vary with the number of peaks to each respective image, the variation and resulting flicker depending upon actual difference in frequency of shutter flicker, or in other words, depending on how much they are out of step.

It is obvious from the above that a current flicker can be avoided in alternating arc projection, only by occasional accidental synchronizing for short periods of time, or by a carefully planned synchronization, together with special shutter design.

It is evident that current flicker is an inherent objection to alternating current arc projection. There are other faults better known, such as the bluish color of the light, the poor concentration of light at the light source focus of condensor, and the noisy hum of the arc.

Without entering into details of these other objections, which are apart from the subject matter of this article, the mention of them seems permissible, as it completes the evidence against alternating current projection, and proves its use poor practice.

Since the direct current arc possesses none of these objections and since a large variety of thoroughly satisfactory and practical apparatus is on the market for converting alternating current to direct current, there seems to be no excuse for

faulty projection, resulting from the use of alternating current.

For alternating current, cored carbons in both upper and lower are always used and these are the same size. This is essential, of course, since the rate of consumption is practically the same for both the upper and lower carbon. On direct current some operators use cored carbons, both upper and lower, and also use the same size carbon for the positive as well as the negative.

While it is sometimes desirable to use cored carbons, both positive and negative, it is the wrong principle to use the same size—the negative carbon should always be smaller than the positive.

For all around service the most advisable ratios will be such that the cross section of the positive carbon would be twice that of the negative carbon, but in actual practice we find that a negative carbon would not have the carrying capacity for the current required for the positive, if the latter were operated at maximum current density. Therefore, the following combinations are a compromise which have been standardized for various current densities. These are as follows:

MAXIMUM CURRENT

Size	Alternating Current	Direct Current	Plain Negatives Direct Current	Metal Coated Neg. Dir. Cur.
1″	100	85–100	3/4 Cored or sol.	3/8 sol. spec. coated
7/8″	90	65–85	3/4 " " "	3/8 " reg. "
3/4″	75	50–65	5/8 " " "	11/32 " " "
5/8″	60	50	1/2 " " "	5/16 " " "
9/16″	50	40		
1/2″	40	35		
7/16″	25	25		
3/8″	15	15		
5/16″	10	10		
7mm	8	8		
6mm	6	6		

In the table of direct current capacities, from the 5/8″ size up, the next smallest sized solid carbon is used as the negative.

Cored negative carbons give steadiness at the cost of the candle power of the arc. Under certain conditions it is possible to operate carbons at somewhat higher current densities than here given and still obtain satisfactory service. It is, however, essential, in order to operate at these higher current densities, that special small diameter metal coated negative carbons be used, the reason being as already mentioned that such combinations can be operated at high current densities, with short and steady arcs free from noise, whereas for the same current density and the use of ordinary negatives, the arcs would be unsteady.

8. Since the light from the direct current arc is emitted from the crater of the positive carbon, it is desirable that the carbon be tilted at such an angle as to point the crater directly at the lens, and still prevent the lower carbon from cutting off the light. An angle of about 25 degrees has become standard for this service. With an alternating current arc the light is given by both carbons, which means that it is desirable to use the carbons more nearly vertical. A slight angle is, however, necessary in order to make draft conditions correct.

9. With alternating current the carrying capacity is limited by the ability of the carbon to carry the current, whereas on direct current, it is limited by the ability of the crater to stand up under high current densities; that is, the 5/8″ carbon can carry 60 amperes alternating current

without undue heating, but on direct current 50 amperes would be the limit, since a higher current value would tend to break down the crater formation with subsequent unsteady operation.

FILM

Motion picture film is a strip of flexible, supple, transparent celluloid $1\frac{3}{8}''$ wide. One side of the film is given an emulsion coating much the same as on an ordinary photographic film pack. The margin of the film is perforated, there being 64 perforations to the foot of film or four on either side of each picture (16 pictures to one foot of film) these perforations are for the purpose of feeding the film through the camera or projector. The film comes to the projectionist on metal reels, each reel containing approximately 1,000 feet of film, generally five or six reels making one feature picture. The projectionist should always examine his film before running it through the projector; this he does by running the film from one reel on to another, by using a rewinding machine and letting the film pass between the first finger and thumb of the left hand; care should be taken to see that all patches are secure, that the film is free from "frame-ups" and that the perforations are in such a condition that the film will pass readily through the projector without jumping off the sprockets. The reels should then be placed in a fireproof film cabinet in chronological order, care being taken to see that the film is wound on reels emulsion side out and that the beginning of the film subject comes off first, in other words that the film does not go through the projector tail-end first. Remember that the film passes through the projector upside down and emulsion side to source of light. As soon as the film has

passed through the projector it should be rewound and placed back into the safety cabinet ready for the next show. The majority of film exchanges request that the film be returned to them unrewound just as it is taken off the projector after it has been run, it being the rule in exchanges that the film be examined starting at the end and working back to the beginning of the subject; this is to eliminate the risk of their sending the picture on to the next theatre, tail-end first. Care should be taken to see that all pieces of film are kept off the floor of the operating and rewinding room; a special can fitted with a self-closing door or lid should be a part of the necessary equipment of the operating room. Film should at all times be handled with great care, as owing to the ingredients from which it is made, nitro-cellulose and camphor, it is highly inflammable. Never under any circumstances expose film near a naked light; do not smoke while handling film or in a room where film is stored; film should not be stored in a warm dry atmosphere unless it is kept in a humidor. Do not attempt to run a show if using inflammable film without having the projector enclosed in an approved fireproof booth; perhaps an editorial we prepared for the Educational Film Magazine on this subject will be appropriate here.

In New York State and, in fact, every State of the Union, certain very stringent rules and regulations have been drawn up and must be complied with before it is possible to obtain a permit for the purpose of showing motion pictures. We advise all those in any way interested in the showing

of motion pictures to get a copy of the law and read it carefully over.

The code distinctly states that no motion-picture machine shall be used unless same has been approved by the Board of Fire Underwriters. This board demands that all motion-picture machine manufacturers shall make the machines as fireproof as possible; the machine must be so constructed that only a short length of film can be exposed while the machine is in operation. The machine must be equipped with an automatic fire shutter, so arranged that the shutter will immediately drop in case of trouble and thus cut off the heat of the arc lamp from the film.

The law then goes on to state that even this machine equipped as it is with all these fire prevention devices shall not be used unless the said machine is installed in a fireproof booth. They are as particular regarding the booth as they are with the machine; the booth must be constructed of asbestos, concrete, brick, or some other approved fireproof material. Certain minimum dimensions are given as the size of the booth and it must have a door that is automatically self-closing. The projector and observation ports in the booth must be equipped with metal or asbestos shutters, so arranged that they will automatically close in case of fire in the booth. There must be a flue or vent running from the booth to the open air to carry off the smoke in case of fire. The booth must also contain fire bucket, pails of sand, and fire extinguishers.

Now that we have a fireproof projecting machine installed in a fireproof booth, the authorities go one better and state that with all these pre-

cautions there is still a great danger of fire unless a duly qualified licensed man is placed in charge of the handling of film and the operating of the projection machine. They demand that theatre managers shall take all these necessary precautions against fire on account of the highly inflammable nature of the film. Both the theatre manager and the professional operator lay themselves open to severe penalties should they not live up to the letter of the law. These rules are not laid down to throw obstacles in the way of those desirous of showing motion pictures; they were drawn up after due and careful consideration for the public safety.

When we stop to consider that a film is run today in a theatre where all these very necessary precautions are taken, and the following day the same film is sent to some class-room or church, there to be run by some amateur operator (whose knowledge of projection is limited to the threading up of the machine and the switching on of the current) who is using a projecting machine set up on the top of some table—minus the booth, minus the various safety devices called for by the authorities, with probably hundreds of youngsters crowded around the machine—we come to the conclusion that either too much precaution is taken in the case of the theatres or not enough in the church and class-room. We come out here and state that it is the latter. There are hundreds of churches, schools, and educational bodies throughout the country which are using inflammable film without taking the necessary precaution against the ever-present fire risk.

When inflammable film is used, it matters not what make of projector you are using, you must install the machine in a fireproof booth that has been approved by the proper authorities, and an experienced man should be placed in charge. The law is very clear and definite on this point.

MOTION PICTURE FILM IN THE MAKING

In order to produce film of the highest quality, the greatest care must always be observed and every process carried on in the cleanest surroundings. The importance of cleanliness alone can be understood when it is considered that any fleck of dirt lodged on the surface of the film will be enlarged many times on the screen. After the process of cutting and rolling the film, each strip of stock is carefully inspected to eliminate every piece of film which contains flaws of any kind whatsoever.

In considering the many steps that are required to make motion picture film, it may be well to group the various processes as follows:

(1) The chemical preparation of the raw materials,

(2) Spreading of the support for the emulsion,

(3) Spreading of the sensitive emulsion in a thin layer on the support and

(4) Slitting of large film rolls into stock sizes, inspection and shipment.

We shall now consider these processes in the order named.

Cotton, which is thoroughly cleansed, is utilized in the manufacture of the transparent cellulose base on which the sensitive photographic mate-

rial is coated. This cotton after being passed through drying machines to remove every vestige of moisture which it contains under ordinary atmospheric conditions, is treated with a mixture of nitric and sulphuric acids to render it soluble.

Special machines, called nitrating centrifugals, are used to mix the cotton with the nitrating acids. These machines consist essentially of large-sized perforated baskets which rotate in vats containing the acid mixture. The cotton is completely immersed in the acid and when the chemical reaction is complete the product, though the same in appearance, is entirely different in chemical nature, as the original cotton has become pyroxyline or nitro-cellulose.

When the acid treatment reaches the exact stage required, the acid must be expelled instantly and the cotton thrown into water to stop the reaction. The treated cotton is next removed to tanks of water for its first washing, and after being rinsed is passed into centrifugals where water is played on it to remove most of the acid, and then conveyed to other tanks where it is thoroughly washed to remove all traces of acid. The excess water is now removed from the cotton, which is then ready for treatment with the solvents in which it readily dissolves, forming a thick viscous fluid resembling honey, which in factory parlance is called "dope."

The dope is passed through an elaborate system of filters, and finally spread in thin layers on the polished surfaces of enormous wheels, where it quickly hardens and becomes a flexible transparent substance, ready to be formed into a backing

for the sensitive coating. It is here especially that the genius of the factory engineers in solving the problem of large-quantity production has been particularly marked. These wheels form part of immense machines several stories high, weighing approximately 150 tons. The accuracy of these machines is such that the variation from the required thickness of .005 inch is not more than one quarter of a thousandth of an inch.

Silver, which forms part of the sensitive emulsion coated on the transparent base, comes in bars which are placed in porcelain crocks containing dilute nitric acid. Silver nitrate is formed by solution in the acid. The solution of silver nitrate is then poured into evaporating dishes which are placed on steam tables where it is heated to facilitate evaporation to the crystallizing point. After a certain amount of the silver nitrate has been crystallized, the crystals and liquid remaining, which is called "mother liquor," are poured off into draining dishes, which allow the mother liquor to drain. The silver nitrate crystals are re-dissolved and re-crystallized until all impurities are removed. Here again we get that search for purity which exemplifies every operation in the making of high-grade photographic film. The pure white silver nitrate crystals are then placed in porcelain draining baskets where as much of the liquid as possible is drained off. The crystals are next placed in shallow trays and allowed to dry at first on open racks and then in drying closets. They are finally placed in covered jars and stored until needed.

We now come to that mysterious compound, the light-sensitive emulsion on which, when coated on

the film base, the invisible or latent image is impressed. By suitable chemical development the image first becomes a negative and is transferred to the positive film and is then ready for projection. From this point all operations in the manufacture of sensitive film are carried on in darkness or dim red light.

To make a sensitive emulsion, a solution of silver nitrate is mixed with potassium bromide dissolved in a solution of gelatine, forming silver bromide which is the compound or emulsion that is sensitive to light.

The emulsion for negative and positive film is fundamentally alike, the former, however, being more sensitive and less contrasty than the latter.

The large rolls of sensitized film are then packed in tin cans and stored until ready for inspection and slitting into strips 1⅜ inches wide and from two hundred to four hundred feet in length.

To manufacture a film product of the high average quality now demanded, minute inspection and test at every step in the manufacture from pyroxyline to finished film is essential. This requires chemists in the laboratories, inspectors in the darkrooms and photographic experts who make practical studio and laboratory tests for speed and quality, to which all film is subjected before being finally approved and passed.

Speed determinations are also made by means of the Hurter-Driffield method and are checked by a Chapman Jones plate tester. In the former, strips of film 7 inches long and 2 inches wide are placed in a rotating black sector so perforated as to give with one exposure a series of gradations

when exposed for a given time in front of a lamp of known candle power. Each exposure is expressed in candle-meter-seconds. The density or amount of silver for each gradation strip is obtained by means of a photometer and a characteristic Hurter and Driffield, or, as it is commonly known, the H. & D. curve plotted. From the curve thus obtained, the amount of latitude in exposure which is permissible can be readily obtained. The curve commences with a decidedly bent section, and merges into a straight line which finally runs into a curve which is the reverse of the first curved portion. The straight line section indicates the latitude of correct exposure. The H. & D. test is only useful to the manufacturer for the control of the product. The Chapman Jones plate tester with which speed tests are checked consists of a series of strips of varying opacities mounted on a glass plate. Exposures of a certain number of candle-meter-seconds are made through these strips and the resulting densities on the film determined.

Both unperforated and perforated film is produced. The greatest care is taken at all times to perforate film accurately, for unless the perforations are absolutely correct in spacing and alignment, unsteadiness both in the camera and the projecting machine will result. Each machine in the Kodak factory is daily subjected to rigid tests; all guides and punches being carefully examined with gauges which show up to ten-thousandths of an inch variation. A length of film is tested for variation in pitch and is also doubled back on itself to see whether the perforations are uniform

or not. Gauge tests are furthermore made for width, and the perforations examined under a magnifying glass to see that their edges are clean-cut and uniform.

The finished film is then wrapped in chemically pure black paper and packed in tin containers which are labeled with the footage length and identification emulsion number, placed in straw-board containers, and is then ready for shipment.

THE TINTING OF MOTION-PICTURE FILM

The problem of suitably coloring the motion picture is now occupying the attention of many serious workers in the industry. Some few years ago the plain black and white picture was in itself a sufficient novelty to interest the public and color was of no particular consequence, providing the story was sufficiently interesting. Times are changing, the public is growing more exacting in its requirements and the demand for color is evident from the fact that from 80% to 90% of the film now being produced is tinted.

In spite of the success attained by many workers in producing multi-color pictures by purely photographic means the expense involved reduces the prospect of the natural color picture coming into universal use for some time to come, so in the interval the majority of film will be colored by improved methods of tinting and toning.

Tinting

Tinting, as usually understood, consists in immersing the film in a solution of dye which colors

the gelatine, causing the whole picture to have a uniform veil of color on the screen, though there are other ways of producing the same effect as follows:

1. By the use of color screens at some point in the path of the beam of light in the projector. The color screens may consist of sheets of colored glass or of dyed gelatine similar to the usual photographic filters, conveniently mounted in a circular rotating holder placed in front of the projector lens. This method is very satisfactory if a long run of film is to receive the same tint, though if the tint has to be changed between scenes some mechanically operated arrangement is necessary.

Interesting effects may be secured by using a compound filter composed of two or more sections placed at a suitable distance in front of the lens, so that one color will diffuse into the other on the screen.

2. By "flood lighting" the screen, which consists in throwing beams of colored light onto the screen from the wings. This method is fairly effective but necessitates the assistance of one or more operators.

3. By coloring the film base. Apart from the manufacturing difficulties involved in producing such film the limited number of prints which could be supplied would not warrant the demand for the infinite variety of shades and tints employed by various producers.

4. By coloring the gelatine by means of inorganic salts. This interesting method depends upon the fact that certain inorganic metallic salts,

such as uranium and iron ferrocyanides, lead sulphide, etc., in the colloidal condition are highly colored. The method of tinting consists in precipitating the colored salts within the gelatine by first immersing the film in a weak solution of— say, uranium nitrate, rinsing and then placing in a weak solution of potassium ferrocyanide and washing. The depth of tint depends on the concentration of the solutions and on the time of rinsing before immersing in the ferrocyanide. The color does not bleed but in view of the labor involved and the limited number of colors available the method is inferior to that of tinting with dyes.

5. The method of tinting with dyes is the most satisfactory and is almost universally employed. The dye can be applied to the film by means of application rollers or by floating the film across the surface of the dye or by spraying, though the method of dipping, as in development, is in most general use.

Success in tinting depends on the correct choice of dyes and the correct methods of their application.

CHOICE OF DYES

Dyes are of two kinds, acid and basic, depending on their chemical composition, acid dyes being alkali salts of organic acids while basic dyes are the chlorides, sulphates, etc., of organic bases. The two classes of dyes may be distinguished as follows:

(a) When a solution of an acid dye is mixed with a solution of a basic dye, both are mutually

precipitated and come out of the solution, and this property is made use of in testing whether a dye is acid or basic. It is simply necessary to add a solution of a known basic dye; for example, methyl violet to the unknown dye solution, and observe if the solution remains clear (indicating a basic dye) or becomes turbid (thus indicating an acid dye).

(b) Another method consists in immersing the edge of a piece of blotting or filter paper in the dye solution. In the case of a basic dye, as the color runs up the paper, a colorless band precedes the band of color as if the paper were filtering the water from the dye, while with an acid dye no such line of demarkation is noticed.

(c) Another interesting property of basic dyes is that an acid solution does not usually dye gelatine as rapidly as a neutral solution, while with most acid dyes the rate of dyeing is considerably increased by adding acid.

None of the above tests is absolutely conclusive, though in the absence of the more refined chemical tests if all three confirm each other they may be considered as conclusive.

In view of the opposite nature of acid and basic dyes, it is obvious that if several dyes are to be mixed one with another to produce intermediate tints they must all be of the same class. Since the number of acid dyes of suitable color is far in excess of the number of basic dyes, thus giving greater selection, and since acid dyes are usually more stable to light, they are the most suitable for tinting.

PROPERTIES OF ACID DYES

Dyes suitable for tinting should possess the following properties:

1. The dye should not "bleed" to any considerable extent when the film is washed; in other words, the rate of removal of the dye should be slow and only a slight amount should wash out in a period of—say five minutes.

In tinting, bleeding is of very considerable importance, since during the period between rinsing after dyeing and the placing of the film on the drying racks, any drops of water on the surface of the film become more or less saturated with dye, and these, after drying remain as spots and irregular markings which are very apparent on the screen.

It is possible in some cases to modify this bleeding by an acid "stop-bath," or by adding acid to the dye-bath, though it may be considered a general rule that the bleeding of a dye is a property particular to itself. In selecting dyes it is therefore necessary to choose only those whose propensity for bleeding is a minimum.

2. The dye should not be precipitated by alum, calcium (lime) magnesium, or iron salts. A large number of dyes are readily precipitated by these salts, the result being that if the water supply contains a slight amount of—say alum or calcium salts, or if the film is for any reason not thoroughly washed after leaving the alum hardening fixing bath, the dye precipitates in the tank as a sludge and produces a spotted effect on the film. Hard water, which may contain carbonates, bi-

carbonates or sulphates of calcium and magnesium, is therefore liable to give trouble with unsuitable dyes. The use of distilled water for mixing the dye solutions will partly eliminate the trouble, though a supply of distilled water is available in very few film laboratories.

In many localities the water supply is treated with compounds containing alum and iron salts to precipitate vegetable colloidal matter in suspension though after settling, the water still contains alum in solution, and also any previously dissolved salts, which cause the trouble.

The dyes recommended below are not readily precipitated by alum, calcium, magnesium, or iron salts and a large number of dyes while otherwise suitable for tinting film have been rejected because they failed to stand this test.

3. The dye should not be "dichroic" or change color (hue) on dilution, otherwise it is difficult to repeat results and match any given tint. The dye should also be fast to light even under the heat of the projector, otherwise local fading would result in patchiness on the screen.

4. The dye solution should not froth readily, otherwise foam accumulates on the surface of the tank, especially when the drum system of tinting is employed and clings to the film even after rinsing.

5. The dye should not be affected by the acid-fixing bath since any fixing solution accidentally splashed thereon will destroy the dye immediately. Great importance has not been attached to this test since hypo should never reach the tinted film.

It has been impossible to collect a complete set of dyes which will pass this test, though in choosing between two otherwise satisfactory dyes the one affected by hypo has been rejected.

6. The dye should be inert and not attack the gelatine coating of the film even after incubating for 24 hours at 212 degrees F. This is of fundamental importance otherwise the film becomes brittle and its wearing qualities are impaired.

BRITTLENESS OF FILM

Complaint is sometimes made that film is lacking in physical properties, and in many cases this is apparently so, but due to no fault in manufacture. Projecting conditions have changed. Whereas 20 to 30 amperes was considered sufficient for projection, owing to longer throws necessary in the larger theatres, many houses are using considerably over 100 amperes. In the interval between successive showings the film has not time to cool, the result is a continual baking of the film which affects its flexibility and with other factors produces brittleness. These factors may be tabulated as follows:

1. The corrosive action of the dye itself. Several dyes when employed at a concentration of 1% attack gelatine readily at 70 degrees F. and vigorously at 80 degrees, especially in the presence of small amounts of acid, producing a marked softening and often partial dissolution of the film. The effect is roughly proportional to the concentration of the dye and to the temperature, and varies with each individual dye.

Experience has shown that the gelatine coating of film which has been softened in this way by the dye becomes brittle on subsequent projection. The effect is due partly to the particular chemical constitution of the dye itself and also to the impurities mixed with the dye. Commercial dyes are prepared by "salting out" the dye by adding common salt, sodium sulphate and other chemicals to the dye solution so that unless the dye is subsequently purified it contains sodium chloride or sodium suphate with more or less iron which has a tendency to harden the film considerably.

2. The hydrolising action of acid which in many cases is added to assist in dyeing. The addition of acid to a solution of an acid dye usually has the effect of increasing the rate of dyeing while in the case of a basic dye the rate of dyeing is diminished. With acid dyes, acid also tends to fix the dye in the gelatine and therefore diminish the rate of bleeding. In such a case only a volatile acid, such as acetic acid, should be used, since this will mostly evaporate on drying. If a solid acid, such as citric or tartaric is used, this remains in the film on drying and under the influence of the heat of the projector, especially in damp weather, the acid soon begins to decompose the gelatine film.

The effect of acid on gelatine is readily seen by adding a few pieces of gelatine to a strong solution of acetic acid. The gelatine soon dissolves, forming a liquid glue which when dry is much more brittle than gelatine.

Acid in any form is therefore undesirable as far as the wearing qualities of film are concerned,

but if it is used the concentration should not exceed 0.05% or 1 part of glacial acetic acid to two thousand (3 oz. per 50 gal.) otherwise softening of the gelatine is liable to occur especially if the temperature of the dye-bath exceeds 70 degrees F.

It is common practice in many film laboratories, when the dye bath works slowly, to add a further quantity of acetic acid to increase the rate of dyeing. This is done repeatedly until the dye-bath contains practically no dye at all and a strong odor of acetic acid is present in the drying room. Such maltreatment of film is responsible for most of the complaints of brittleness and is to be deplored. The cost of the dye is insignificant as compared with the value of the film treated so that a dye-bath of sufficient strength should be made in the first place and a strong solution of the dye added as required in order to revive the bath. Fifty gallons of dye bath of a concentration of 0.2% will usually tint 40,000 feet of film.

CHOICE OF COLORS

Although it is possible to match any tint by suitable admixture of one or more of three colors, magenta, yellow and blue green, when mixing colors in this way the mixing must be done with great precision since a slight variation in the quantity of any one of the ingredients produces a marked effect, so that it is simpler to include intermediate colors, such as orange, green, etc., as standard tints.

Seven standard tints have been chosen: namely, red, scarlet, yellow, light green, green, blue and

violet. The problem of matching tints with standards is then a simple matter.

In selecting any particular dye, account has been taken of the purity of its color. Some dyes have a muddy appearance as if a certain amount of black dye had been mixed with it. This has the effect of diminishing the screen brightness so that in order to maintain constant screen intensity more current must be used in the projector. The purity of color of the dyes selected below is sufficient for all practical purposes.

AMERICAN FILM TINTING DYES

The following American made dyes which fulfill the above conditions as nearly as possible are recommended for film tinting:

Tint	Name of Dye	Obtained From
Cine Red	Amaranth	Calco Chemical Co., N. Y. C.
Cine Scarlet	Crocein Scarlet MOO	Natl Aniline & Chem. Co., N. Y. C.
Cine Yellow	Quinolin Yellow	Natl. Aniline & Chem. Co., N. Y. C.
Cine Lt. Green.	Napthol Green Conc.	White Tar Aniline Corp., 56 Vesey St., N. Y. C.
Cine Green	Acid Green L	Natl. Aniline & Chem. Co., N. Y. C.
	Wool Green B	White Tar Aniline Corp., N. Y. C.
Cine Blue	Direct Blue 5B	Essex Aniline Wks., 39 Oliver St., Boston, Mass.
	Acid Blue GR	Newport Chem. Wks., 120 Broadway, N. Y. C.
Cine Violet	Buffalo Fast Violet B	Natl. Aniline & Chem. Co., N. Y. C.

The above list of dyes has been selected after testing more than five hundred dye samples, but is necessarily incomplete because new dyes have appeared on the market since these tests were made.

In cases where alternative dyes have been recommended, they may differ slightly in regard to color, rate of bleeding, etc., and are therefore not strictly interchangeable. This is due to different methods of manufacture. In the following formulæ the first dyes indicated on the above list were used.

The strength of the dyes may vary from batch to batch, the same dyes made by different makers differing particularly in this respect, so that when purchasing it is desirable to secure a statement of the percentage of pure dye in the sample. As stated above, a certain percentage of salt or sodium sulphates is present in most commercial dyes, so that when comparing prices the amount of impurity present should be taken into consideration.

METHOD OF PREPARING THE DIE SOLUTION

Dissolve the solid dyes in as small an amount of hot water as possible, and filter through fine muslin. Pour hot water over any residue remaining to insure thorough solution of the dye, and dilute the solution in the tank to the required volume at 65 degrees (F).

NATURE OF POSITIVE FILM

Only good snappy positive film may be successfully tinted, since tinting tends to reduce contrast.

The depth of the tint obtained depends on the following factors:

1. NATURE AND STRENGTH OF THE DYE-BATH

Except in special cases, such as fire scenes, sunset and moonlight effects, it is very undesirable

to employ strong tints, since apart from the displeasing effect and irritation to the eye, the dyes produce a slight softening of the gelatine film when used at 80° (F) in a 1% solution.

FORMULAE FOR TINTING AT 65° (F).

TINT NO.	DYE	AVOIRDUPOIS	METRIC	TIME OF TINTING
1	Cine Red	2 lbs.	1000 grams	3 minutes
	Water	50 gals.	200 liters	
2	Cine Red	13 ozs.	400 grams	3 minutes
	Water	50 gals.	200 liters	
3	Cine Scarlet	26 ozs.	800 grams	3 minutes
	Water	50 gals.	200 liters	
4	Cine Scarlet	13 ozs.	400 grams	3 minutes
	Water	50 gals.	200 liters	
5	Cine Yellow	18 ozs.	540 grams	3 minutes
	Cine Scarlet	1 oz. 150 grains	40 grams	
	Water	50 gals.	200 liters	
6	Cine Yellow	18 ozs.	540 grams	3 minutes
	Cine Scarlet	1 oz. 150 grains	40 grams	
	Water	50 gals.	200 liters	
7	Cine Yellow	13 ozs.	400 grams	3 minutes
	Water	50 gals.	200 liters	
8	Cine Lt. Green	26 ozs.	800 grams	3 minutes
	Water	50 gals.	200 liters	
9	Cine Green	26 ozs.	800 grams	3 minutes
	Water	50 gals.	200 liters	
10	Cine Blue	13 ozs.	400 grams	3 minutes
	Water	50 gals.	200 liters	
11	Cine Blue	13 ozs.	400 grams	1 minute
	Water	50 gals.	200 liters	
12	Cine Violet	13 ozs.	400 grams	3 minutes
	Water	50 gals.	200 liters	

Should it be necessary to employ concentrated baths in summer, either cool the dye bath or use a suitable hardener. This will be unnecessary if hardener is employed in the fixing bath after development, but otherwise if formalin (40%) be added to the dye-bath to the extent of 1 volume to 400 volumes of dye solution, no trouble will be encountered. During the winter months when it is

advisable to treat all film after developing and fixing with glycerine, the latter may be incorporated with the dye bath, thereby eliminating an extra operation. The strength of the glycerine should be 2%, or two volumes per one hundred volumes of dye solution. In most cases, however, the addition of glycerine considerably retards the rate of dyeing and in order to obtain the same degree of tinting in a given time, the concentration of the dye bath should be increased accordingly.

When delicate tints are employed, the effect is both to remove the contrasting black and white effect, and to add a touch of warmth to the black deposit of silver, even in cases where the highlights are insufficiently stained to be noticeable. The result in many cases is equal to that obtained by partial toning.

2. TEMPERATURE OF THE DYE-BATH

Although temperature has little effect on the rate of dyeing with the dyes recommended, when used without the addition of acid, it is advisable in all cases to work at 65° to 70° F. to produce uniform results and remove any danger of softening the film.

3. TIME OF DYEING

In order to duplicate any particular tint with a given dye-bath the film may be dyed either by time or by inspection. Dyeing by time is reliable if the dye-bath does not contain acid, though if acid is present, in time the acidity decreases, causing a slowing down of the rate of dyeing, so that it becomes necessary to judge the progress of dyeing by inspection.

If two or more tints of the same color are required, it is better to vary the time of dyeing rather than to vary the dilution of the bath, as a means of reducing the number of individual dye-baths to a minimum, providing the time of dyeing for the lighter tint is not less than one minute, which time is considered a minimum for the production of uniform results and for complete control of the dyeing operations.

The time of dyeing also depends somewhat on the previous handling of the film. Film which has been fixed in a bath containing ordinary—or chrome alum, dyes more quickly than that created with plain hypo and hardened with formalin.

It is probable, therefore, that small traces of alum, which serve as a mordant for the dye, are left in the film even after prolonged washing.

Should the film for any reason be over-dyed, a small portion of the dye may be removed by washing for 10 to 15 minutes, though the fastness of the dyes to bleeding will permit only slight mistakes to be rectified in this manner.

LIFE OF THE DYE-BATH

This averages about 40,000 feet of film per 50 gallons of dye-bath. As the rate of dyeing slows down the bath should be revived by adding a concentrated solution of the dye and not by adding acid. When the bath becomes muddy, especially in warm weather, it should be renewed.

METHOD OF PROCEDURE

Either the "drum" or the "rack" method may be employed, the rack being agitated slightly to insure even dyeing and prevent accumulation of air

bubbles, after which the film should be given a thorough rinsing in plain water.

Before drying films on racks it is advisable to set the rack at a slight angle for a few minutes, to enable the surplus water to drain off more readily through the perforations. If drums are used for drying it is advisable to remove the surplus water by whirling the drum previous to drying.

If uniform results are to be obtained, film should never be passed through the projector before either tinting or toning.

HOW TO OBTAIN INTERMEDIATE TINTS

Sample tints may be readily obtained by making a trial with a small amount of solution on a short length of film, taking care to match the tint in artificial light and not by daylight.

When matching think of the tint as being made up of one or more of the colors, red, yellow and blue. Colors such as orange are made by mixing yellow and red, violet by mixing red and blue, and green by mixing yellow and blue. Browns are obtained by mixing all three colors, red, yellow and blue.

LOCAL AND MULTIPLE TINTING

Very pleasing effects may be secured by locally tinting a portion of the film picture. This can be done either by coloring each picture separately by hand of by cutting a stencil and applying the dye through the stencil by application rollers or by spraying, or a resist such as a transparent varnish may be applied either by hand or by stencil to those portions which are not to receive dye and

the film immersed in the dye solution in the usual way. Multiple tinting is executed in the same way.

LIGHT TRANSMISSION

The amount of light cut off from the screen as a result of tinting depends upon the nature of

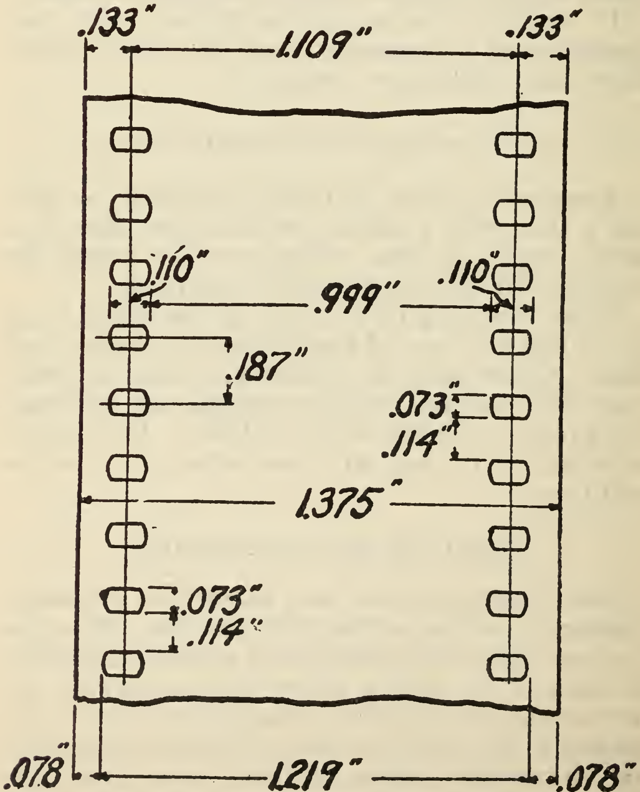


FIG. 73

the particular dye, the concentration of dye in the film, and on the purity of color of the dye. An interesting series of measurements recently made in the Research Laboratory of the Eastman Kodak Company show that the screen brightness is diminished by from 25% to 95% as a result of tinting. Excepting in special cases, therefore, it is very desirable to keep the tints as light as possible or at least no deeper than is required to produce the necessary color sensation.

TROUBLES IN TINTING

Streaks and uneven coloring may be caused by:

(a) Grease on the film. Film should never be projected before being tinted.

(b) Excessive bleeding of the dye, allowing the film to stand too long after rinsing and before placing on the drying rack, or insufficient squeegeeing of the film when placing on the drying rack.

(c) Too low a humidity in the drying room. If the air in the drying room is too dry, while the film stands on the rack previous to placing on the drying reel, the edges of the film commence to dry while the center is still moist with water charged with dye which has bled from the film. Even after squeegeeing under such conditions drying marks will be produced and are apparent on the screen as streaks. The remedy is to keep the relative humidity of the drying room around 60% to 70% and to squeegee the film either by means of a blast of air or by chamois as quickly as possible. All drying rooms should be equipped with

a recording hydrometer placed in close proximity to the drying reels.

PRECIPITATION OF THE DYE

This is usually due to the presence of alum, calcium, magnesium or iron salts in the water supply as described above.

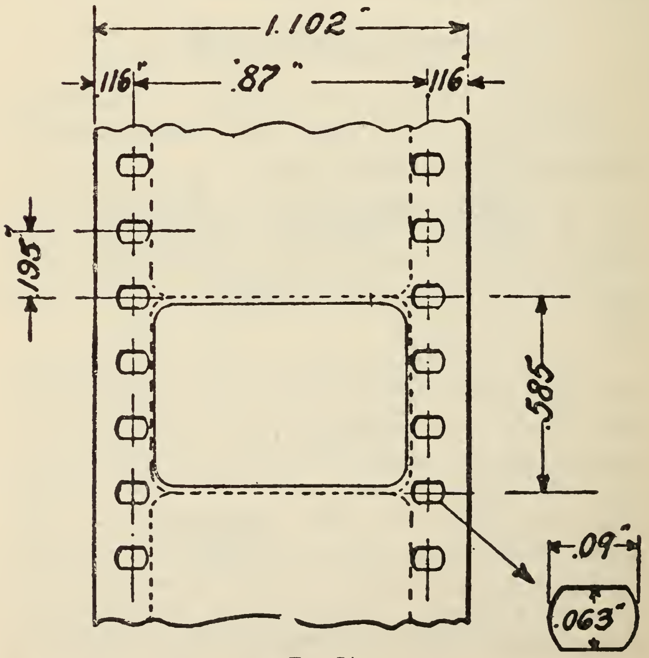


Fig. 74
Safety Standard

THEATRE DESIGN TO SAFEGUARD FROM FIRE AND PANIC

The adoption of standards in the design of theatres, to safeguard the public from fire and panic, is a subject which is worthy of consideration by a society interested in standardizing the various parts of the industry.

After every great theatre fire in which there has been a great loss of life, there is considerable agitation on the part of officials and the public in general to try to prevent a repetition of the disaster. The usual result is the drawing of more stringent building ordinances and restrictions, but the general public soon forgets, inspectors become lax, and the laws are not enforced. Although there have been no great theatre fires within the last few years, constant vigilance and agitation by officials and those in a position to suggest will lessen the chances of a holocaust. Also in the smaller cities and towns which at the present time support large theaters, there is an absence of carefully drawn building ordinances regulating theatre construction in so far as the safety of the audience is concerned. In fact, in many fairly large cities, there are no regulations whatever concerning even the most important safeguards. The safety of the patrons is then in the hands of the architect and owner. The architect may not be sufficiently familiar with the many details of this specialized form of building and their great importance, or the owner may, in his desire to cut the cost of the building or to increase the seating

capacity, overcome the objections of his architect, endangering the safety of the public. Again, in some towns, there still exist many ordinances that were drafted when the actual dangers of the cinematograph were greatly magnified by men who had little knowledge of the actual conditions. The ever-increasing popularity of the theatre must not be allowed to suffer from accidents due to improper construction or regulation thereof, and the Society of Motion Picture Engineers would do well to recommend these or other similar standards to safeguard the industry where no local regulations exist.

Before discussing these standards let us briefly review, in a general way, how the loss of life usually comes about in a theatre fire and what means and safeguards should be employed to insure the safety of the audience. By so doing, we can tell why the requirements enumerated below should be rigidly adhered to.

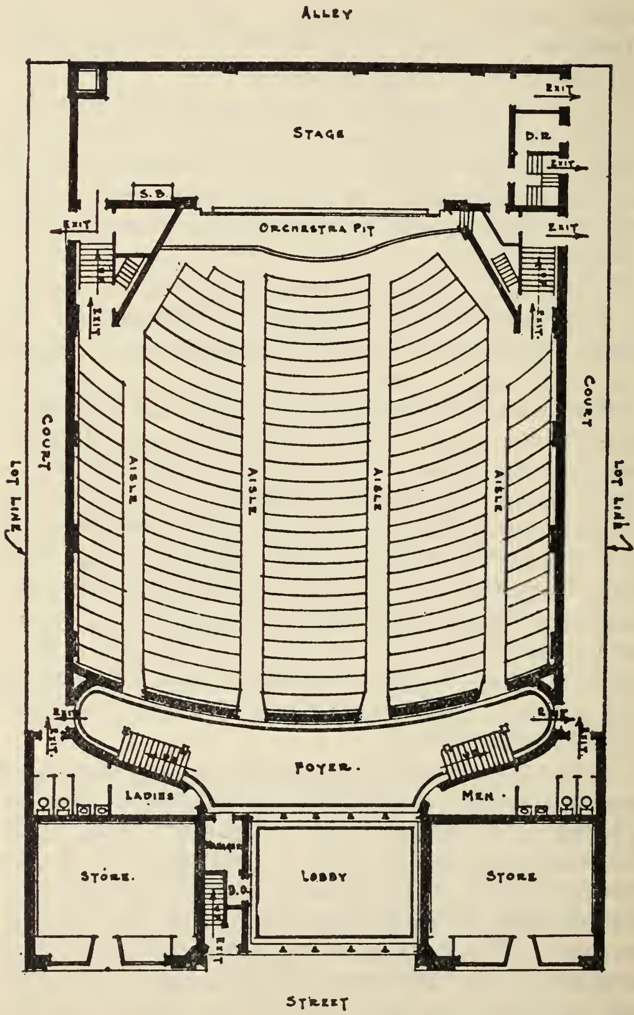
In the hundred years (1797-1897) at least 9,355 persons lost their lives in theatre fires, according to William Paul Gerhard in his book on "Safety from Fire and Panic in Theatres." About 14 per cent of these fires broke out while an audience was in the building. In the greater number of fires the loss of life has resulted from the rapid spread of flame on a stage covered with scenery, followed within two or three minutes by an outpouring of suffocating smoke through the proscenium arch into the top of the auditorium, before those in the balconies and galleries could escape. In this way many people in the galleries lost their lives by burning, suffocation due to heat, smoke, fire gases, by shock or fright, and by the

crush or jam of the panic in which many were trampled to death; most of this happened within five minutes of the first flame.

In the few fires which have occurred in theatres without a stage and used for the presentation of motion pictures only, the loss of life has occurred by the burning film instead of stage scenery, but the fear and results of panic are the same in any public gathering.

Therefore, the chief considerations for safety of the audience are: Removal of smoke and fire gases, accomplished by the quick opening of ample automatic smoke vents on the stage or in the projection room; the equipment of the stage and other hazardous rooms with automatic sprinklers to smother the flame; the confining of the fire to the stage by means of a fire-resisting curtain at the proscenium opening or the closing of portholes of the projection room by fire shutters, sufficient light supplied by emergency controlled lights, as darkness leads to confusion, struggle, etc.; ample exits, stairways and passages to the main floor and exterior courts to permit of quick escape of the audience; and fireproof construction to retard the progress of fire.

In the preparation of this article, the ordinances regulating the construction of theatres in Boston, Chicago, Los Angeles, New Orleans, New York, Philadelphia, San Francisco, Seattle and St. Louis were reviewed and tabulated, as well as the recommendations of the National Board of Fire Underwriters. The standards recommended here are a conclusion or summary of these regulations and are presented in section form, each part of the building covered in a separate section.



ALLEY
STAGE
D.R.
EXIT
S.B.
ORCHESTRA PIT
EXIT
COURT
LOT LINE
AISLE
AISLE
AISLE
AISLE
FOYER.
LADIES
MEN.
STORE.
LOBBY
STORE
B.O.
EXIT
STREET

FIG. 75

As the great majority of theatres now being built are of a larger seating capacity than 300 and most of them have a stage, it will be advisable to limit our discussion to this type. However, in Chicago and in some other cities, there is a special class for theatres over 300, but less than 1,000 seating capacity for the exhibition of moving pictures only, no stage being permitted, and for this type the standards recommended for the balance of the building should be strictly followed.

SECTION 1. BUILDINGS INCLUDED

Every theatre or other building used for the presentation of motion pictures, theatricals or for public entertainment of any kind and accommodating more than 300 persons shall be built to comply with the following sections. These requirements shall apply to every building hereafter erected and to any building remodeled for the above purpose and shall govern the planning and construction whether a stage is provided for or not.

SECTION 2. FRONTAGES

Every building covered by the above shall have frontage at least on one street. Where the building is not on a corner lot it shall have an open court or passageway on each side of the auditorium extending from the proscenium wall to the street in front. Or, in case there is a street or alley at the rear of the stage, such passage may extend from the foyer to such street or alley. (See Fig. 75.) Where a building is on a corner lot and one side of the auditorium fronts

on the street or an alley, the passage may be omitted on this side. In a building used for the presentation of motion pictures only, having no stage and all seats are on the main floor, it will be permissible to omit the courts or passage on the sides of the auditorium, provided that there is no cross aisle and there are not more than twenty-five rows of seats and that direct exits shall be provided at both ends of each aisle of such capacity as provided in Section 10, and leading into street at front and street or alley in the rear. Courts or passages shall be of width provided in Section 11.

SECTION 3. CONSTRUCTION

All buildings of this class and buildings built in connection shall be of fireproof construction throughout, except as follows: Steel of the gridiron shall not be fireproofed. Roof trusses of steel need not be fireproofed unless there is a building over the auditorium, but they shall have a suspended ceiling of metal lath and plaster under them. The steel supporting removable floor traps in the stage floor need not be fireproofed.

SECTION 4. BUILDINGS IN CONNECTION

Any building built in connection with the theatre shall be of fireproof construction throughout. The building shall be separated from every part of the theatre with a solid masonry wall of thickness required for the main walls of the building. Any part of the building over the auditorium or entrances shall be separated by a fireproof floor. No structure of any kind shall be permitted over the stage. If the theatre is used for presenta-

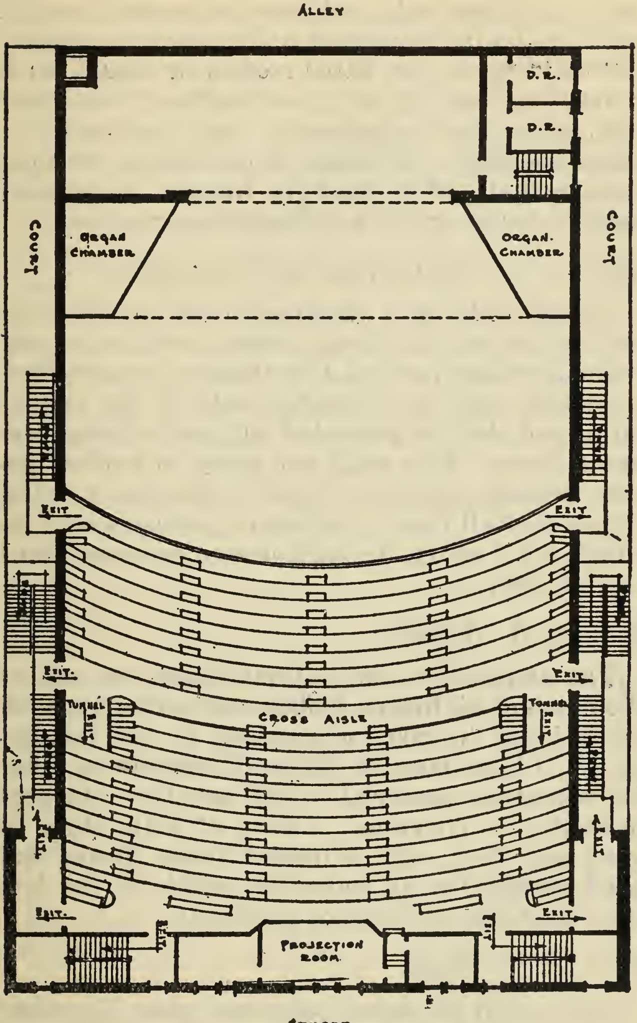

ALLEY
D.R.
D.R.
COURT
ORGAN CHAMBER
ORGAN. CHAMBER
COURT
EXIT
EXIT
EXIT
EXIT
TUNNEL
TUNNEL
CROSS AISLE
EXIT
EXIT
PROJECTION ROOM
STREET

FIG. 76

tion of pictures only and there is no stage and all seats are on the main floor and no part of connecting building is over three stories in height, such connecting building may be of ordinary construction, providing it is separated from the theatre as above specified. Buildings in connection with the theatre shall not be used for factory, warehouse, lodging house or for any hazardous purpose.

Section 5. Separation of Auditorium

There shall be a fireproof wall between the auditorium and the foyer, lobby, corridor or any room forming part of the theatre in each tier. Openings shall be permitted only at the end of aisles and shall be protected with self-closing fireproof doors. This shall not apply to motion-picture houses only, as covered in Section 2. The capacity of all foyers, lobbies or passages shall be equal to 1½ sq. ft. for each person accommodated on that tier.

Section 6. Floors

The auditorium and balcony floors, as well as the floors of all foyers, lobbies and corridors, shall be designed to carry a live load of 100 lbs. per sq. ft. Floors may be either of concrete or other incombustible material or of wood on sleepers imbedded in concrete. Floors at exits shall be level and flush with adjacent inside floors and shall extend for an unbroken width of not less than four feet in front of each exit.

Section 7. Seats

Seats shall be placed not closer than 32 inches back to back. Seats shall be firmly secured to the

floor. There shall not be more than six seats between any seat and an aisle.

SECTION 8. AISLES

Aisles with seats on both sides shall not be less than 34 inches wide at the proscenium end, those with seats on one side only 30 inches at proscenium end and all aisles shall increase in width one inch per five feet toward the exits. Unless direct exits are provided at the end of each aisle on the main floor, there shall be a cross aisle every fifteen rows connecting to a direct exit, leading to the outside court or passage. There shall be a direct exit by tunnels or a cross aisle leading to tunnels and emergency exits every 12 feet in the height of the balcony. (See Fig. 76.) Platforms in the balcony shall not be higher than 21 inches and shall have a minimum width of 32 inches. When the rise of seat platform is less than 4 inches per foot, floor of aisle shall be made as a gradient. When steps are used in the aisles, risers shall not be more than 8 inches high and treads not less than 10 inches wide. The width of tunnels in the balcony shall be equal to 20 inches per 100 seating capacity that they control but they shall not be less in width than the aisle leading to them nor less than 4 feet wide.

SECTION 9. ENTRANCES

The width of the main entrance doors and the lobby shall be based on 20 inches for each 100 seats provided. No entrance shall be less than 15 feet wide. There shall be a separate entrance from the street for each gallery or balcony over the first balcony. The floor at the main entrance

shall be at the sidewalk level. No auditorium shall have the highest part of its main floor more than 3 feet above the level of the sidewalk at the entrance. All doors in the entrances shall open out in a recess in the wall so as not to block the passage when open, and no doorway shall be less than 5 feet wide. There shall be at least two entrances or exits to every tier accommodating 300 or less, and at least three entrances to every tier between 300 and 500. Over 500 capacity there shall be added 20 inches for each additional 100 seats, to the total width of entrance. All passages or corridors throughout the interior shall be made 20 inches in width for each 100 persons, but they shall have a minimum width of 4 feet.

Section 10. Emergency Exits

Emergency exits shall be provided of the same capacity as the entrances to each tier, opening into the alley at the rear or courts at side. There shall be at least two such exits for each tier on each side of the auditorium and shall be preferably at the top and bottom level of such tier. (See Fig. 76) No such exit shall be less than 4 feet wide. Doors shall open out in a recess in the wall same as for entrances and shall be provided with panic exit bolts arranged to open by pressure against them.

Section 11. Passages or Courts

There shall be provided as in Section 2, courts on each side open to the sky of the following widths: 6 ft. wide up to 600 capacity; 8 ft. from 600 to 1000; 9 ft. from 1000 to 1500; and 10 ft. wide over 1500 total capacity of the theatre. These

passages shall continue either to the street or thoroughfare in front or in back of the building and shall not be closed by any locked gate or doorway. If it is necessary to pass through any section of the building, a corridor may be used having brick enclosing walls, and fireproof ceiling. The width of corridor shall be the same as that of passage and height shall not be less than 8 feet. The slope of the floor of such passages will not be greater than one foot in twelve feet, except an incline not less than ten ft. long may have a slope of two ft. in twelve ft. to reach the sidewalk or alley level. No steps will be permitted in the floor of such court.

SECTION 12. FIRE ESCAPES

The emergency exits of each tier shall be connected by exterior balconies and stairs leading from such exits to the passage level. (See Fig. 76) They shall be of steel construction built to carry a live load of 100 pounds per sq. ft. They shall be covered with a hood of sheet metal or enclosed when passing over an exit below. If the flight nearest the court level is counterbalanced, it shall be lowered during the performance. Outside balconies shall be as wide as the exit doorways fronting on them. The width of stairways shall be equal to ten inches for each 100 persons that they may serve, but no stairway shall be less than 3 feet 8 inches wide, and steps shall have a rise of not more than 8½ inches and a tread not less than 9½ inches. There shall be no openings in the theatre wall between the outside balconies and stairways and their covers except the required exits and no person of the audience shall be

obliged to pass more than one exit doorway after reaching an outside balcony to get to the ground. (See Fig. 76) Each tier of dressing rooms shall be connected by an exterior balcony and stairway to the ground level. Such stair and balcony shall be of same construction as above, but may be three feet wide.

SECTION 13. STAIRS

All interior stairs shall be constructed of incombustible materials and designed to carry a live load of 100 lbs. per sq. ft. No winders shall be permitted. There shall be at least one or more separate and distinct stairways for each balcony and two for each gallery to the sidewalk level. The gallery stairs shall extend to the top level and shall have exits leading to it from each tier of that gallery. Such stairs shall rise from the entrance lobby or vestibule inside the building and the bottom run of such stairs shall lead toward the street and the last riser shall not be further than 60 feet from such street. (See Fig. 75) No flight of stairs shall have less than three risers nor more than fifteen between landings. On stairs which return on themselves the landing shall be the full width of both flights with corners curved not less than two feet radius. Stairs with a right-angle turn shall have a landing the full width of the flight. Risers shall not be more than 7½ inches high and treads not less than 10 inches wide. The width of stairs shall be based on 20 inches per 100 persons served, but no stair shall be less than 4 ft. 6 in. wide. There shall be a handrail on both sides of stairs placed about 3 ft. above the steps and 3 in. from wall and on flights

over 8 ft. wide there shall be a double handrail down the center of such flight with double newels 5 ft. high at ends. The stairs to the top gallery shall be entirely enclosed but the stairway to the balcony may be open on one side. Stairways on the stage leading to dressing rooms shall be not less than 3 ft. wide. There shall be at least one stairway separated from the stage by a masonry wall leading from each tier of dressing rooms direct to the vestibuled entry of the stage. There shall be a stair to gridiron continuing to roof of stage. Such stair may be circular and may be thirty inches wide.

Section 14. Stage Walls and Curtain

There shall be a solid masonry wall of the same thickness as the main wall of the building separating the stage portion from the auditorium. This wall shall extend at least 4 feet above the stage roof or the auditorium roof if the latter is higher. The proscenium opening shall be covered with a curtain of asbestos, or steel and asbestos, or other fireproof construction. It shall lap at least one foot on each side of the opening and two feet at the top and shall slide at least 6 inches in metal grooves fastened to the brick wall. The curtain shall be in constant use as the regular curtain and act drop. There shall be but four other openings in the proscenium wall, two on the stage level and two below. These openings shall be no greater than 21 sq. ft. each and shall be protected with automatic fire doors. Other openings in the stage walls shall be protected with fire doors or wire glass windows, in metal frames. No iron guards shall be placed on these windows. There shall

be at least two exits not less than 4 ft. wide on the stage level one on either side of the stage leading to the outside. These must be vestibuled. (See Fig. 75) Every building used for the presentation of motion pictures only as specified in Section 2, shall not have a stage or proscenium opening. The screen for the picture shall be placed not further than 6 inches from the rear wall of the theatre and a platform not exceeding 80 sq. ft. may be placed in front of it. No rooms of any kind shall be placed between the auditorium and the rear wall of the building.

Section 15. Dressing Rooms

Dressing rooms shall not be placed on or under the stage or in or under the auditorium. The dressing room section shall be separated from the stage or auditorium by a masonry wall at least 8 inches thick and all openings to the stage shall be protected with self-closing fire doors. All partitions, doors and fittings of every description shall be of incombustible material. All dressing rooms shall be ventilated by fire windows to street or court not less than 24 sq. ft. in area.

Section 16. Stage Ventilators

Over the stage there shall be one or more ventilators built of incombustible material having a free opening and sectional area of at least 10 per cent of the area of the stage. This ventilator shall have either a damper or sliding or hinged sash arranged to open in case of fire. This construction of the damper and the operating mechanism shall be massive and the damper or sash shall open by force of gravity sufficient effectively to overcome

the effects of neglect, rust, dirt, frost, snow or expansion by heat or warping of framework. If glass is used it shall be protected against falling on the stage by a wire screen so arranged that if clogged the effective area will not be reduced or the operating mechanism interfered with. Automatic fusible links shall be used to open the damper or sash in case of fire in addition to manual control provided by a cord run to point on the stage designated by the superintendent.

SECTION 17. PROTECTION OF STAGE

There shall be a standard wet pipe system of automatic sprinklers controlling the entire theatre except the auditorium, lobbies and foyers. Sprinkler openings shall be placed around the proscenium opening in back of the curtain so as to form a water curtain when they are opened. There shall be a standard system of standpipes with two 2½-inch diameter outlets at each level of the auditorium and at stage level. Also one outlet at each dressing-room level and gridiron. Each outlet shall be provided with a sufficient length of 1½-inch hose so as to reach all parts of the tier which it controls. There shall be a full equipment of axes, hooks, chemical fire extinguishers and water barrels placed in various parts of the stage to combat the spread of fire. All stage scenery, curtains and decorations made of combustible material shall be painted with a non-combustible material.

SECTION 18. LIGHTING

Electric light only shall be permitted on the auditorium and stage portions except that gas

light may be used to indicate exits. If exits are indicated by electric light, this service shall have a separate control and be connected ahead of the main service.

Section 19. Boiler Rooms and Carpenter Shop

Boiler rooms, carpenter or scenery painting shops shall be separated from the auditorium and stage by a fireproof floor or masonry wall or both, and have automatic fire doors in the connecting openings.

Section 20. Stage Floors

The gridiron shall have a metal lattice floor designed to carry a live load of 75 pounds per sq. ft. Fly galleries shall be of fireproof construction designed to carry 90 pounds per sq. ft. All of the stage except the part usually covered by floor traps of no greater width than the proscenium opening and depth from proscenium to rear wall shall be of fireproof construction. The non-fireproof part shall be of heavy timber or steel beam construction. All shall be designed to carry at least 100 pounds live load per sq. ft.

Section 21. Projection Room

Every projection room shall be large enough to permit the projectionist to walk freely on three sides of the machine. Walls shall be of concrete or tile at least 4 inches thick and all doors leading from the room to be self-closing fire doors. Openings or picture projection shall be protected with heavy sheet metal drops arranged to slide in grooves. They shall be controlled by cords arranged in such a manner that they will automati-

cally close at the outbreak of fire. All shelving and fittings shall be of incombustible material and all films not in use shall be kept in tight-covered metal cans. There shall be a ventilator at least 12 inches in diameter leading from the top of the room to the outside air.

Conclusion

If these requirements are carefully followed out in the planning of a theatre, it would appear that the building should be safe. The fallacy of this was proved by the Iroquois disaster in Chicago. This theatre was the last word in fireproof construction and careful planning. In his paper on "The Safeguard of Life in Theatres," by President John R. Freeman, presented to the American Society of Mechanical Engineers, he states: "At the time of the fire in the Iroquois, that fire pails and soda water fire extinguishers were absent and that ventilating skylights over the stage were blocked so that they could not slide open, and that exits were poorly marked, and that there was a delay in providing the fire hose on the stage."

Therefore, combined with these standard requirements, must be the careful attention by the management as well as frequent and efficient inspection by the authorities. On account of the many places on a theatre stage and adjoining property rooms where rubbish and junk may accumulate without being noticed because of the lack of light, it is very necessary that the management exercise constant vigilance to prevent the danger of fire.

In defense of some of the old non-fireproof theatres one might say that as far as safety to the

audience is concerned, it is far better to have very clear and intelligent planning, such that the patrons can easily find their way out, than absolute fireproof construction, as the great loss of life has usually happened within five minutes of the first flame. So, if a theatre can be emptied in two to three minutes, the audience will hardly suffer even if the building is of ordinary construction. In the Iroquois, the underwriter loss was practically nothing while the human toll was enormous. Mr. E. O. Sachs, the London architect, in his account of some one thousand theatre fires, states that the requirements of safety to the audience should be placed in the following order: "Good planning first, efficient and constant watching by the management, careful and frequent inspection, and fire-resisting construction last."

At present untold sums are being spent for theatres. Each new building being larger or more lavishly decorated than any other. Picture presentation has developed into one of the highest arts, requiring wonderful stage settings, orchestration and lighting effects. The management is constantly on the alert to invent something new to provide amusement and enjoyment for their patrons.

THE VENTILATING, HEATING AND COOLING OF THEATRES

Rapid as has been the development of the motion-picture theatre, in one department there has been but little visible progress—ventilation.

We therefore approached the Monsoon Cooling System of New York City who are experts on this subject, and they were pleased to have their chief engineer, E. L. Garfield, co-operate with us in the preparation of a technical article on the subject of theatre ventilation.

Some blame attaches to the exhibitor because of the scant attention he has given to this important subject. But the underlying cause, to my mind, is the general lack of specialized knowledge on theatre ventilation.

Winter ventilation, for instance, is almost universally treated with absolute disregard for its effect on the heating. The natural result is a house warm enough, but ill-smelling and stuffy; or a house with a pure atmosphere, but a bit too chilly for comfort.

The usual treatment of summer ventilation and cooling leaves out of consideration the high percentage of moisture, humidity, to be found in the atmosphere in hot weather. And yet this humidity causes more discomfort in a warm theatre than the high temperature itself.

Let us first consider the proper method of ventilating a theatre in cold weather. It must be recognized from the outset that this is impossible

without the loss of some heat. How great this heat loss is depends on:

1.—The frequency of air change.

2.—The degree of scientific skill applied to the problem.

The two generally accepted methods of heating and ventilating a theatre may be classified as follows:

1.—All direct radiation for heat, with exhaust fans for ventilation.

2.—Indirect radiation or warmed air supply for both heating and ventilation, combined with a small amount of direct radiation.

Direct radiation comprises the use of the ordinary steam or water radiators, the heat being applied directly to the air in the immediate vicinity of each radiator.

Indirect radiation (or tempered air supply) consists of warming fresh air and forcing it into the auditorium at one or more points.

Mainly for reasons of economy, I would use the first method outlined above for the smaller theatre—say, one up to 800 seats. It is simple and practical. With sufficient radiation, properly distributed, there can be no great difficulty in maintaining a fairly even temperature.

Successfully to combine this method of heating with good ventilation demands careful study so as to effect the proper air change with minimum heat loss, and without objectionable drafts. I have little regard for exhausting at the ceiling line because it assumes that the warm air at the ceiling is necessarily foul air.

This is wrong: foul air is heavy. It has been breathed and become laden with moisture, carbon

dioxide and organic impurities thrown off by the lungs. Naturally, being heavy, it lies close to the floor line; and because it lies near the floor line, it is at this point that we must exhaust if we would remove the foul, ill-smelling air.

Furthermore, this heavy air does not readily absorb heat. It is therefore the coldest air in the house; and if we exhaust it we pass out with it the smallest possible amount of heat. Consequently, from the standpoint of heat economy, it costs least to remove this air, while it costs most to remove air at the ceiling line.

With these facts established, it is obvious that the air should be exhausted at the floor line near the stage, or at the end opposite from the entrance doors. The fan apparatus should effect a complete air change within a certain limited period, to be decided on by a competent ventilating engineer. Such an air change, calculated on ordinary winter temperatures, might prove too frequent during a few unusually cold periods. The thing to do then is to cut down the air change slightly, in the interests of heat economy by reducing the speed of the fan.

The only possible objection to this method of heating and ventilating is the possible slight tendency to drafts through the doors, but this can be compensated for by placing extra radiation at the entrances.

Heating and ventilating in this manner will produce fairly satisfactory results, and its cost is not out of proportion to the cost of the average house of 800 seats. It could not be improved upon except by the use of indirect heating, usually too expensive for the small theatre.

In the larger house the cost of indirect heating does not loom up so large in proportion to the cost of the complete building. In fact, the cost may prove in most cases to be less than that of direct heating. And, certainly, in view of the splendid results, the indirect method is far more desirable.

In laying out an indirect heating and ventilating system for the larger house, warm air supply units are located at the stage end (opposite from the entrance doors). These supply the required amount of fresh air at a temperature of 70° or over. It is imperative that large fans be used, so that the apparatus can be run at low speed, handling the air at low velocity, thus insuring absence of drafts, of noise and of vibration.

The fresh air supply is taken at least 20 feet above ground level, so that it is pure and free from dust. In this way, we eliminate the necessity for an air-washer, which is expensive, requires constant attention and is objectionable for other reasons. The roof or the attic is usually the best location for the heating and ventilating equipments.

The air blown into the theatre finds its way out through openings at the floor line but, to insure positive circulation, exhaust fans are sometimes advisable. A large part of the air supplied naturally passes out through the entrance doors and also through openings in the rear of the balcony, if there are any. The fundamental principle is to keep removing the air from the floor line or breathing zone, and to allow the warm, fresh air blown in to settle like a blanket of warmth evenly over the entire auditorium.

Two desirable advantages that appeal instantly to the theatre manager are these:

1. No inrush of cold air from outdoors when the entrance doors are open. On the contrary, an outward motion of warmed air, due to slight pressure maintained by heating fans.

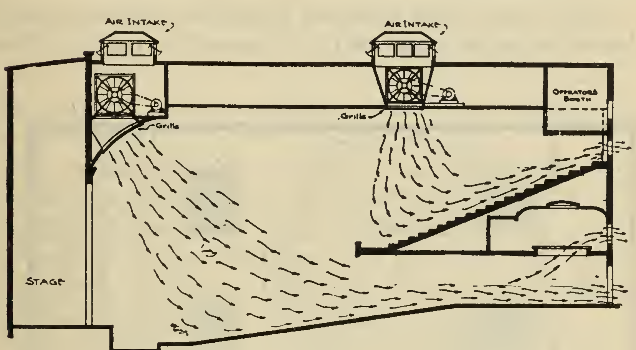


FIG. 77

2. House heated very rapidly before opening, as theatre air can be passed and re-passed several times through heaters (re-circulated).

Such a system is all that is required during the time that the auditorium is occupied by the audience. However, it would be well to provide some direct radiation to allow for heat losses through exposed walls, although the heat radiated by persons in the audience will, in a large measure, compensate for this particular heat loss.

This small amount of direct radiation is also of good use at times—overnight, particularly—when

the temperature falls below freezing point, with danger to water pipes, etc. For this we need just enough direct radiation to keep the temperature at 35 degrees F, as it is not economical to run the fans for heating when the theatre is not occupied and ventilation is not required. The dressing-rooms, toilets, rest-rooms, etc., have the usual direct radiation.

Extremely cold weather that falls below normal is unusual and generally of short duration. For

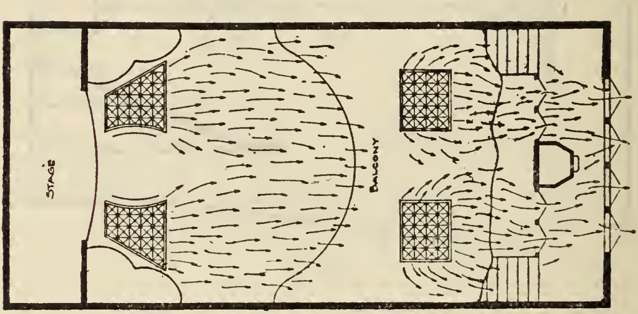


FIG. 78

this reason, it is not a great hardship to sacrifice a small part of our fresh air supply for fuel economy, particularly as the system is designed for maximum fresh air supply and therefore permits of some reduction. During these periods some of the warm air already blown into the theatre is brought back to the heating units and mixed with fresh, outdoor air. By the use of an arrangement of dampers, it is possible to obtain a mixture of fresh air and re-circulated air in proportion to meet any unusual drop in temperature. This fea-

ture is utilized only during the few short periods of extreme cold.

When absolutely perfect results are desired—and finances permit—a profitable investment is a system of thermostatic control of mixing dampers, a thermostatic control of steam valves, or a combination of both. With this system the lower the temperature, the greater the quantity of theatre air re-circulated and mixed with fresh air. On the other hand, a rise in temperature is accompanied by an automatic shutting off of steam in part of the indirect heaters, so reducing the temperature of the fresh air supply.

And now summer ventilation and cooling. At this season of the year an enormous quantity of moisture is thrown off by the human body, and the problem then becomes one of removing the air in such volume as to remove with it this moisture as rapidly as it is formed.

Actually, there is no binding necessity to lower the temperature. The point at issue is to make the human body comfortable, and this can easily be done by creating a breeze, passing it over and around every person in the audience and carrying away the bodily heat and, especially, *evaporating the moisture constantly forming on the skin.* It is simply taking advantage of an old principle, the practical working efficiency of which is convincingly demonstrated every time a perspiring person takes a trolley or automobile ride on a hot day. It's the breeze that cools. It can be nothing else, since the temperature is no lower.

The cost of cooling by the breeze method is very small in comparison with the lower temperature method. All that is necessary is sufficient

fan capacity to effect a very rapid air change—from ten to fifteen times that required for winter ventilation. It will be found that this is sufficient to create a perceptible movement of air that will prove entirely satisfactory. It may be honestly advertised as a "cooling system" and can be depended upon to keep the house comfortable in the hottest summer weather.

As with the winter ventilation, best results can be expected only if the "cooling system" is laid out by a competent engineer who has had practical experience in this line of work. Unless this precaution is taken, there can be no safe assurance that the air currents are evenly distributed over the house — that the breezes can be felt throughout, that they are not too strong in some quarters as to be objectionable.

It is equally important that a fan apparatus be specified, designed specially for moving tremendous volumes of air at low velocity and operating slowly enough to be silent.

An economical arrangement, for a theatre under construction is to arrange the fan apparatus so that part of the cooling and ventilating fans are used with the indirect heaters to form the heating and ventilating units for winter operation. Or, stated the other way, the fans used in the heating and ventilating units may also be used for cooling in summer, in combination with auxiliary cooling equipment to give the additional air volume required in hot weather.

The cooling and ventilating system alone, without heating, can be installed in any theatre, no matter how old, at any time.

Ventilation of theatres is now receiving more attention than ever. And the time is coming— soon, too— when the problem of ventilating will receive fully as much attention as any other connected with the designing and building of theatres.

Hot weather cooling, too, will receive more consideration. And why not? If it is profitable to heat a theatre in winter to attract or keep business, why not cool the house in summer for the same reason?

As the importance of these subjects is better appreciated, it will be realized more and more that they should be handled, not by hit-or-miss guesswork, but by competent engineers who know by scientific training and experience what is needed and how to provide it.

LIGHTING FOR MOTION PICTURE THEATRES

The photoplay is becoming an instrument of culture with practically unlimited possibilities. With the growing appreciation of the public, the demand for special effects in the presentation of the photoplay is increasing. Resourceful producers and exhibitors are supplying the demands of a critical public for more genuine art and as a result the silent drama demands for its temple a specially constructed building of architectural magnificence equipped with the best mechanical devices, most perfect ventilation, and an attractive and harmonious system of illumination.

Because the theatre is used largely at night, light is one of the best means of making it attractive. The lighting of the theatre has ceased to be merely a matter of engineering-detail. The illuminating engineer and others responsible for the lighting of a playhouse, must possess imagination. The illumination effects should be designed to supplement the drama by producing an atmosphere harmonizing with the play and not detracting from it.

The problem of lighting in the photoplay house differs in many ways from that in the so-called legitimate theatre especially with reference to the auditorium, orchestra pit, stage and proscenium arch, and consists not so much in providing the proper and sufficient intensity of light, but in securing the correct gradation of light and color.

No attempt will be made here to trace the his-

tory of the theatre lighting art; the development of which has been, in the opinion of some, retarded by playhouse traditions; but to present some of the methods of present practice in theatre lighting. The development of lamps and their accessories has brought about many important

FIG. 79
Flood Lighting of Theatre

changes in the lighting of this class of interior, and their application has taught us much about the value of lighting as a medium for advertising, as well as for artistic and spectacular effects.

The best results in the art of theatre lighting can be attained only by careful study of the various means that can be used, and by noting the effects of each method, on the actual operation

of the house. The method that furnishes satisfactory illumination, that is novel and effective, is greatly desired by the prospective theatre owner.

It should be kept in mind that good lighting properly applied, will do as much as any other fea-

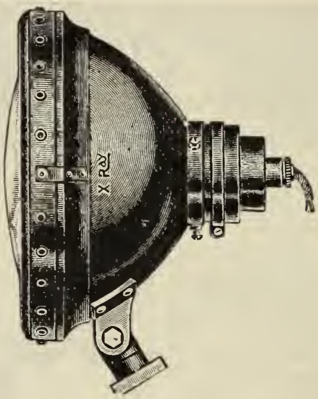


FIG. 80
Lamp for Flood Lighting

ture to elevate the theatre to the point of its maximum usefulness and attractiveness.

Lighting the Exterior

Even from a distance of several blocks away, patrons can be attracted to the playhouse by special lighting effects. The recent development of flood lighting, using projector units, provides the theatre owner a means of effective advertising in addition to the usual signs, etc. The system gives very attractive results at a comparatively small cost, and does not mar the building surface since

in most cases the Units can be placed in an accessible location at a considerable distance from the building.

The method of bringing the building into prominence by outlining with bare lamps has been used. Although this method is satisfactory in some cases, it does not light the building, but rather obliterates the details of design. The

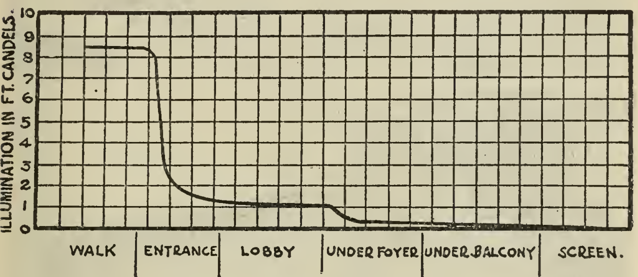


FIG. 81

newer scheme for lighting the exterior, an example of which is shown in Figure 79, fixes the shape, design and location of the building on the mind of the observer. This in reality is the first step in the process of attracting the patron to the playhouse.

In some instances, the most effective results are obtained by combining outline lighting with the flood-lighting method. Architects are often willing to alter architectural details so that flood-lighting may be employed. In some cases special cornices are constructed or in others architects extend marquees out from the building for the accommodation of the flood-lighting projectors.

An illustration of a type of lighting unit that has been very successful for the flood-lighting of a theatre is shown in Figure 80. The flood-lighting projector is not designed to throw a concentrated beam such as is obtained with a search-

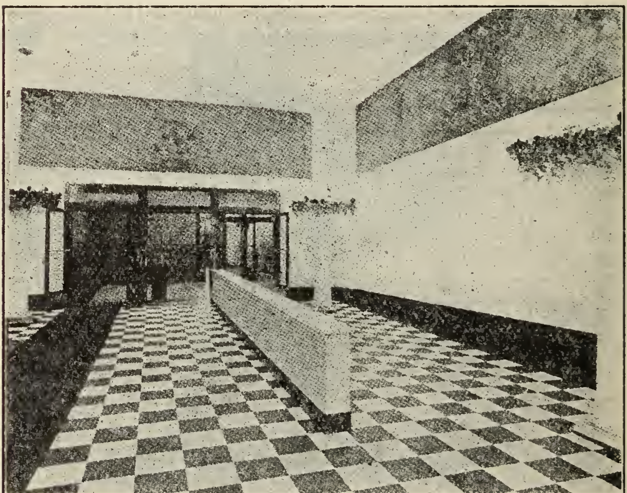


FIG. 82
Theatre Lobby Using Pedestal Lighting Method

light, but rather to spread the lighting evenly over a large area. Projector units can now be obtained for use with lamps ranging from 200-watts up to 1,500-watts.

Entrance

A bright, warm, and attractive lighting scheme should be adopted for the entrance of the theatre. This is probably the brightest spot in the whole

lighting scheme of the playhouse with the possible exception of the stage, and the lighting should therefore be carefully planned so as to have the maximum attractiveness with a minimum of glare.

One of the fundamental points to be kept in

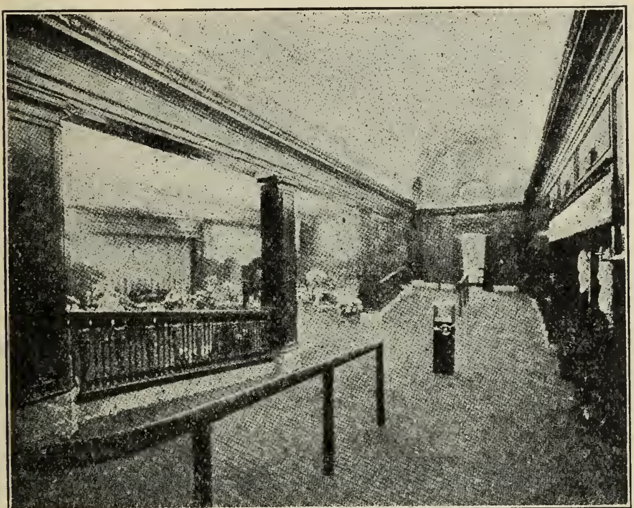


FIG. 83
Cove Lighting and Indirect Portable Lamps

mind in planning theatre lighting is that the whole illumination scheme should be arranged so that a suitable transition in brightness is afforded in passing from the street through the entrance and lobby into the dimly lighted auditorium. The visual shocks that come with sudden changes of intensity will be practically eliminated if this principle is carefully applied. The eye thus be-

comes accustomed to the darkened surroundings gradually.

The accompanying diagram in Figure 81 shows in a graphical way the small steps or differences in illumination value in various portions of the Merrill Theatre in Milwaukee, Wis. It will be noted that the intensity varies from 8 ft. candles at the entrance to practically zero at the screen.

Lobby and Foyer

The foyer and lobby afford probably better than any other portion of the theatre an opportunity for working out novel and individual methods of lighting treatment. Attractive and impressive results can be obtained here without the use of glaring exposed lamps that so often create an atmosphere of garish cheapness. The intensity of light should be more subdued than for the entrance of the theatre as in Fig. 81, thus reducing the contrast between the bright street illumination and that of the dimly lighted auditorium. Many schemes have been adopted for lobby lighting. Hanging fixtures of metal, composition, glass or crystal, illumination from coves and cornices, lighting standards, portable lamps, wall brackets, etc. The lobby shown in Figure 82 illustrates the use of special lighting standards. This lobby is 30 ft. by 50 ft.—has a ceiling 20 ft. high. Four 8 ft. standards light the entire space. Each is equipped with four 100-watt lamps burning in silvered indirect lighting reflectors.

When we consider that the wattage expenditure is only slightly more than one watt per square foot, this is a very effective and economical way to illuminate the lobby. The method eliminates

glare and tends to bring out the decorative touches that have been carefully added to make the lobby attractive.

With much the same effect, but with the lighting accomplished in an entirely different manner, the lobby in Figure 83 is given as an example of

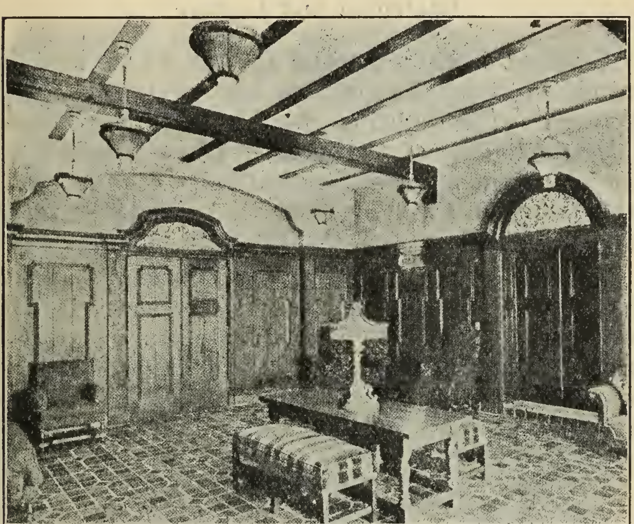


FIG. 84
Silk Fixture Lighting Effect

cove or cornice lighting. Cove lighting has been known for many years to be an ideal method, but only since the production of the high efficiency lamps have the many possibilities for illumination of interiors by this method become apparent. One of the pleasing features of the cove method is that it uniformly illuminates the ceiling and

when properly planned no splashes of light or shadows are present to indicate the position of the individual lighting units in the cove. Cove lighting requires more careful planning than the ordinary lighting problem in order that the results be economical and pleasing.

Restroom and Lounge

Comfort is the essential feature to be kept in mind in the illumination of restrooms and lounges. The lighting should be of a subdued intensity. One of the usual methods consists in the employment of decorative units such as portable lamps and wall brackets that provide a tinted lighting effect.

A typical example of lounge lighting is shown in Figure 84—the Men's Room in a theatre in Milwaukee. In this case a silk bowl fixture produces general illumination of a diffused character. The warmth of the colored silk bowl adds to the artistic value of the interior.

Auditorium

The lighting of the auditorium has probably been given more attention recently than that of any other portion of the theatre. Recent practices in auditorium lighting have led to the more or less general adoption of the indirect lighting system as the logical method for this portion of the theatre, using variations as to color effects, as well as controllable gradations of the intensity of the light. The lighting may be accomplished by means of hanging fixtures, from cornices, coves, wall brackets, balcony rails, etc., depending upon

the personal liking of the owner or the architectural influences of the interior.

It has come to be a necessity that at least two intensities of illumination be provided for the auditorium. First, a dim lighting during progress of the show, and a brighter intensity for in-

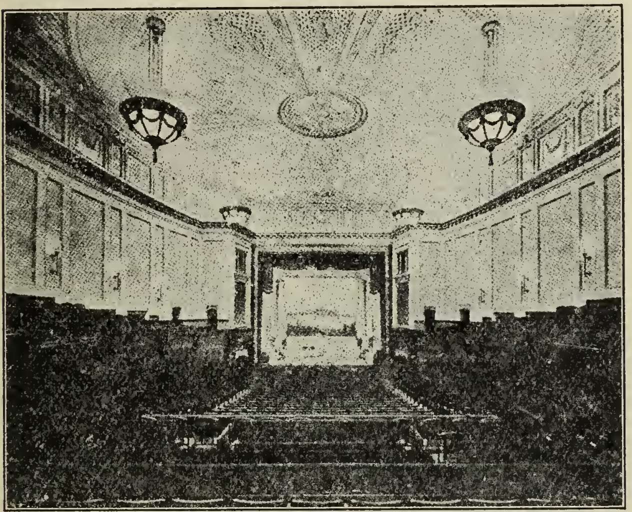


FIG. 85
Auditorium Lighting by Using Large Fixtures

termissions. Dim lighting while the pictures are being shown assists the ushers in seating the patrons, produces a more cheerful place of entertainment and gives to the patrons a sense of safety and security. A dim illumination can be carefully calculated to be of such intensity as not to interfere in any way with the clearness of the

picture on the screen, and furthermore not reduce the ability of clearly seeing about the room.

Dim and bright lighting effects are easily ob-

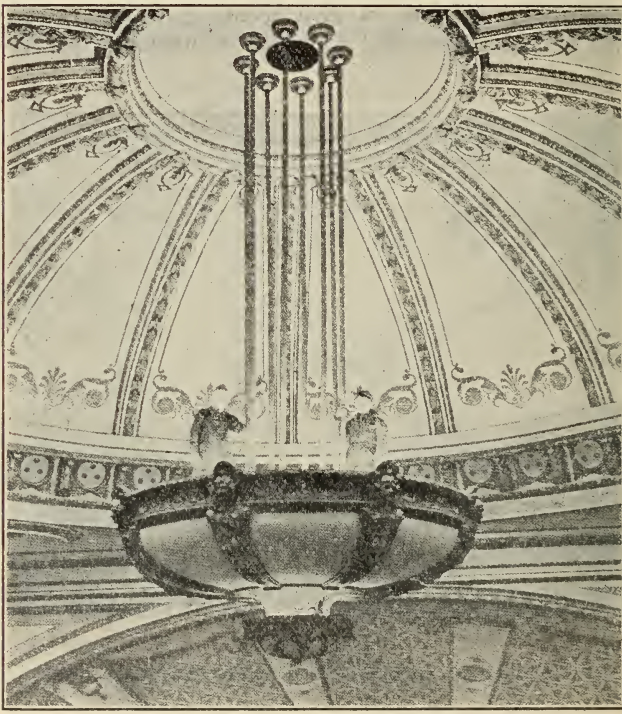


FIG. 86
Fifteen-Foot Indirect Auditorium Lighting Fixture

tained by employing dimmers or by wiring lamps in the lighting units on separate circuits, controlled from the operator's box.

In a careful investigation recently made by Mr.

L. A. Jones of the Research Laboratories of the Eastman Kodak Co. the following conclusions regarding intensities for auditoriums were arrived at:

The illuminations should vary on 1/10 ft. candle at the front of the theatre to 2/10 ft. candles at the rear while the pictures are being exhibited. With the intensity graduated as mentioned ordinary newspaper print can be read with ease by an observer. This amount of illumination will not decrease in any way the quality of the projected picture. However, in order to accomplish results that are satisfactory, the light must be properly distributed throughout the interior and all bright areas or points of intense light should be eliminated.

In addition to the requirements of the auditorium illumination color effects are coming to be more essential in the production of photoplays, in suiting the lighting to the action and the atmosphere of the play. The theatre of the future will no doubt utilize harmonious lighting effects in the presentations. The means for doing this are now within the reach of exhibitors.

The present fashions in theatre lighting are no doubt giving the greatest impetus to the use of colored or tinted illumination and there exists a great opportunity in the playhouse for reaching and developing in the public an appreciation for color. The art of light will educate the average eye to gradations of color to which it is now blind.

There is every reason to believe that lighting can be made to change with the emotional changes

of the play, melting one mood into another. For instance, for night scenes, illumination in the auditorium should be diminished to preserve the proper brightness ratio, and in the case of sunset or sun-rise, the effect may be increased by a simultaneous increase of the brightness in the auditorium.

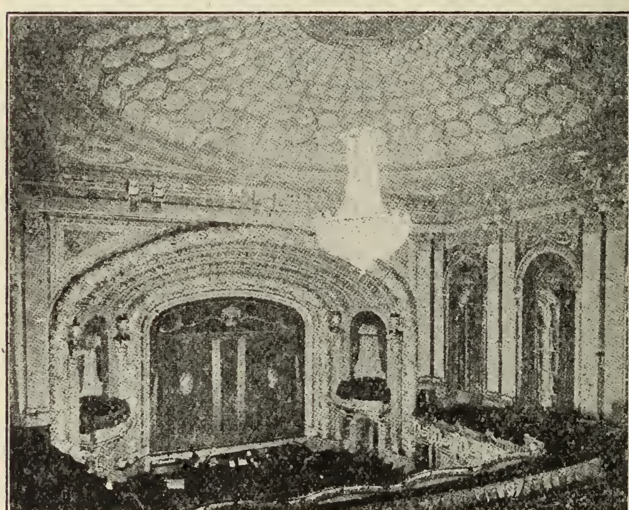


FIG. 87
Crystal Auditorium Fixture

Modern practice shows that colored lights are sometimes used entirely for auditorium lighting, with the white or untinted light entirely eliminated. In some cases a blue light is used for the dim illumination and in other instances amber tone is employed while the pictures are being shown.

We have been handicapped more or less in the use of color lighting in the general illumination of the theatre, because of the mediums with which we have had to work. These mediums have in the past included colored fabrics, gelatine screens, dipped lamps and sheet glass, giving fairly satisfactory results. However, since the development of the high efficiency lamps, the heat factor has become very important and the color devices mentioned above will not entirely fill the requirements because of burning of the mediums. This condition of course brings about a loss in the character and efficiency of colored light.

Dipped and colored lamps are useful where the heat factor is not great, but they do not meet the requirements in all cases, especially where the maintenance is a large item, and replacements are expensive.

Because of the lack of stability in color effects, and because of replacements in the medium, a new type of color slide of special heat resisting glass with the color incorporated in it has recently been developed, and seems to have solved many difficult problems for this class of installation.

With the proper application of these plates for the lighting of the auditorium and the stage, a more rapid advancement in the art of color in lighting is possible without the handicap of the fading out of the medium.

The following examples of auditorium lighting will be of interest as indicating the various methods that are being employed for producing the lighting results.

As a first example, Figure 85 shows how the hanging lighting fixture is employed. In this

theatre, four large luminous type indirect fixtures 72 inches in diameter furnish white and colored lighting effects. The color combinations are obtained by using special colored slides placed above the reflector units in the bowl. In this particular case the lamps for the color units burn in a horizontal position, thus concentrating the maximum of heat on the color slide. This condition brought about the necessity of securing a color medium that is practically permanent, not only as far as the color itself is concerned, but also one that would not crack with subjection to the high temperature.

Another interesting example of lighting with fixtures is to be found in the theatre illustrated in Figure 86. The fixture shown is probably the largest indirect lighting fixture ever installed. This enormous unit is 15 ft. in diameter and contains 118 lamps. The main bowl has 100-200 watt lamps in special indirect lighting reflectors. The lower bowl contains 18-60 watt lamps. This lower bowl serves to illuminate the large bowl and is also used for emergency lighting.

The large fixture is suspended by eight 2-inch pipes, 25 ft. long, and hangs in the center of the dome of the auditorium—weighs approximately 5,500 pounds, and is finished in ivory and gold. The auxiliary lighting in other portions of the theatre not affected by the central fixture is done by means of sixteen smaller fixtures similar to the large one.

Color lighting is also a feature of this installation. In the central fixture the 100-200 watt lamps are divided into four groups of 25 each, with red, amber, blue and white. The colors are

secured by natural colored cover glasses, placed above the reflectors. The same scheme is carried out for the small fixtures. It might be mentioned

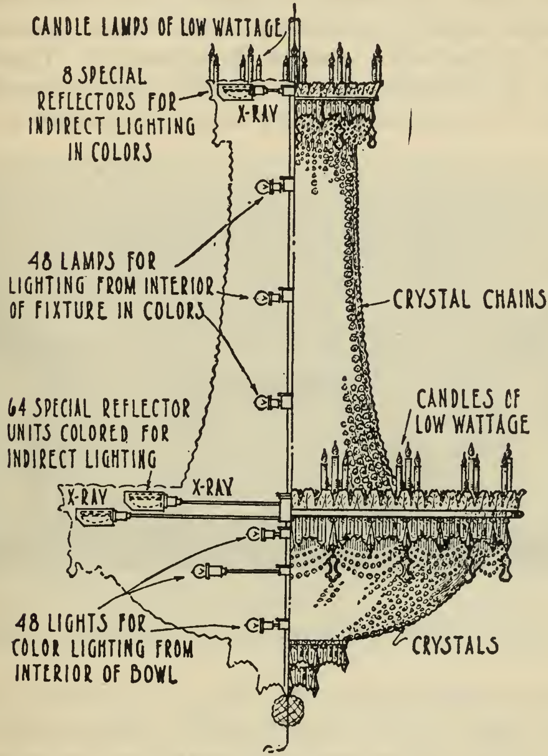


FIG. 88

in this connection that one of the interesting treatments of the lighting in this theatre is the floodlighting of the proscenium arch by twelve 1,000-watt projector units.

In one of the theatres in Illinois all of the principal lighting of the auditorium with the exception of the under the balcony section, and for the proscenium arch, comes from a large crystal chandelier, as shown in Figure 87. This fixture has a total capacity of about 16,350 watts, measures 9 ft. in diameter, and 17 ft. in height. The wiring is arranged in 18 circuits, and serves the many individual lighting units consisting of in-

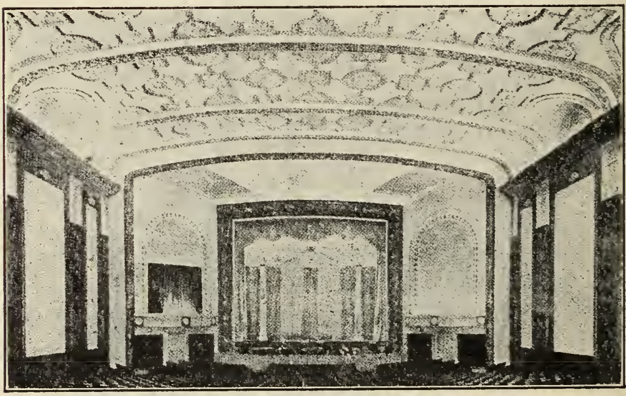


Fig. 89
Auditorium Lighting by Cove Method

direct reflecting devices, color attachments, and the lamps in the interior of the fixture body.

Crystal pieces are being employed in many of the modern theatres. It is therefore of interest to know how the modern crystal chandelier may be employed as an effective lighting fixture without robbing it of its artistic character. Figure 88 shows the interior arrangements and will give

an idea how the fixture may be retained in all its beauty and yet have the added qualities of being light-giving and glareless. This fixture illustrates a radical departure in theatre lighting, and also shows what can be done in combining the artists's skill with practical illumination effects.

The general tendency in theatre lighting is to get away entirely from the use of hanging fix-

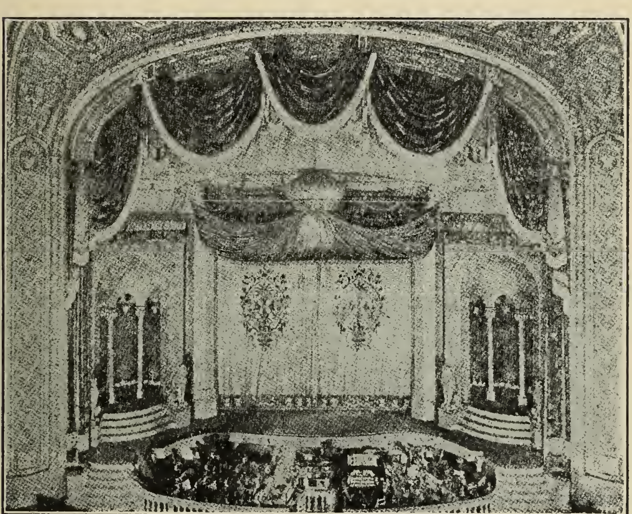


FIG. 90

tures, employing methods of concealed lighting. Some of the most interesting and pleasing installations have been made without fixtures. For the theatre auditorium especially, the elimination of the hanging fixtures increases the spacious appearance of the interior, and also offers the least obstruction to the view of the

patrons and to the projection of the pictures. One of the interesting examples of this form of lighting is illustrated in Figure 89. The lighting equipment in this case is contained in the cornice near the ceiling on two sides of the room. Four series of lighting units are employed, one for white lighting, and one each of the colors, red, green and blue. Standard 200-watt Mazda lamps are used in silvered one-piece corrugated reflec-

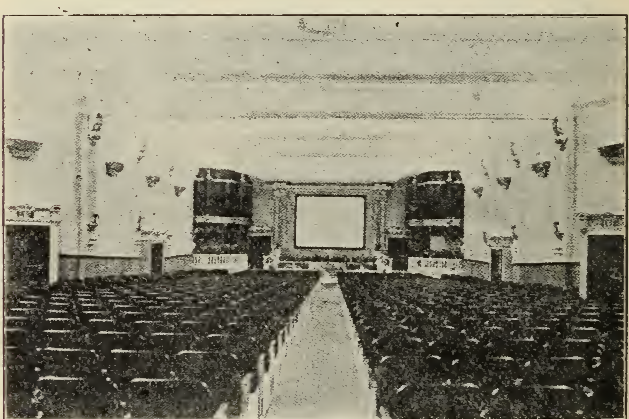


FIG. 91

tors. Color screens of glass are mounted over the openings of lighting units.

A system of dimmers in the circuit of the lighting units provides an easy means by which the lighting units may be lighted so gradually that one is scarcely aware of the increasing intensity. Then the colors of red, green, blue, and various combinations of these colors can be passed through to clear white lighting gradually receding

to almost actual darkness, without a noticeable flicker.

Figure 90 shows another example of the cove lighting method in which the reflecting devices and lamps are installed in coves at the base of the ceiling domes. In this theatre, the Tivoli of Chicago, the main dome contains a large number of 60-watt lamps on 8-inch centers with special mirrored reflectors. The smaller dome contains the same type of equipment with 50-watt lamps.

The finish of the ceiling of the domes is aluminum leaf and gives extremely pleasing lighting effects when the various colors are played upon it. Many special features are employed for other portions of the theatre, such as the side balustrade, under the balcony, the organ grills, the steps at the side of the stage, etc.

An interesting way in which lighting effects may be obtained from ornamental wall boxes is shown in Figure 91. It will be noted that the side walls of the room are divided architecturally into panels which provide a pleasing arrangement for the lighting units. One wall box equipped with special reflectors is located in each of the panels. Each of the wall boxes contains three lighting units wired on two circuits. One unit provides the dim illumination during the performance, while all the units burning during the intermission give a bright illumination. In installations of this character, boxes should be located a sufficient distance from the ceiling to produce an even brightness over the ceiling area.

By working the lighting units into the decorative elements of the room, all lamps are entirely hidden from view, yet the interior is illuminated

by means of equipment which appears to be a decorative feature rather than a lighting fixture.

Another method which offers great possibilities in the lighting of theatre auditorium is illustrated in Figure 95. This balcony view shows that considerable ingenuity has been used in concealing lamps and reflector equipment along the front of the balcony rail. To one seated in the balcony no

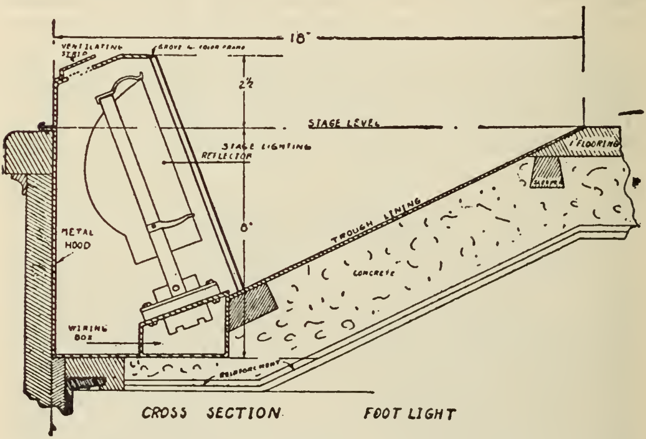


FIG. 92

lamps are visible and yet the auditorium is flooded with diffused illumination. When viewing the balcony from the stage it is not at once apparent that the projecting compartment has been added so well does it fit into the architectural treatment of the house.

Special Lighting Features

Many of the larger theatres are providing special arrangements whereby a flood of light can

be concentrated upon the orchestra during the overtures and other special musical numbers. With the auditorium light subdued the orchestra is brought out in bold contrast to the surroundings tending to keep the attention of the audience upon the musical number. An example of an orchestra pit lighted in this manner is shown in Figure 96. The methods for producing this concentration of light are various. Sometimes pro-

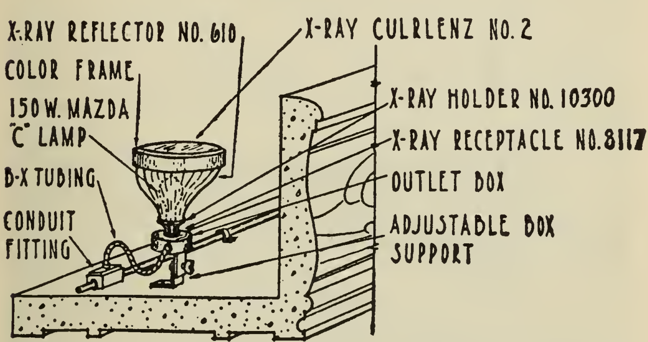


FIG. 93

jectors are concealed above the ceiling, the light beams coming through an opening. When the orchestra pit is well back under the proscenium arch the units are placed among the borders.

In many theatres a feature is made of the lighting of the proscenium arch in order to bring out the beauty of the architectural treatment. A unique method recently installed is shown in Figure 93. The units in this case were placed in the false boxes at either side of the arch. The location of the boxes can be seen by referring

to Figure 93. It will be noted that the supporting device for the reflector units in this case are adjustable, making it possible to point the reflected beam in any direction to secure the proper placing and distribution to the light from the units. Special heat-resisting colored cover plates are used above the reflectors, thus allowing for color effects to be played upon the arch in conjunction with corresponding tints in the auditorium from the principal lighting fixture.

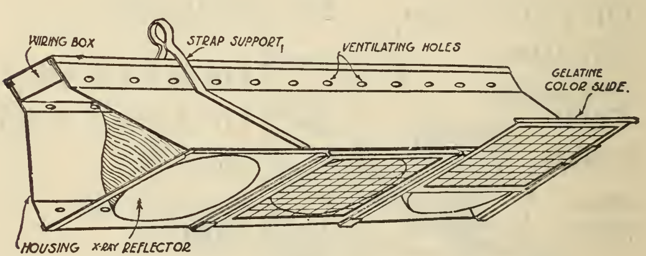


Fig. 94

It is possible in practically every theatre to add interesting artistic touches with special lighting effects. An example of interest is to be found in the theatre illustrated in Figure 90, where the steps leading up on each side of the stage are made of glass and illuminated from below. The light is in colors and changes to correspond with the changes in the general illumination of the interior.

A simple means of getting an effective result upon the screen, draperies and curtains is accomplished by a projecting colored light from the lantern.

STAGE LIGHTING

The stage is the center of interest. The picture, the orchestra, the settings for prologues and special features, combine to make the stage the point about which everything focuses.

In the lighting of the stage, the theatre has probably kept closer to traditional methods than

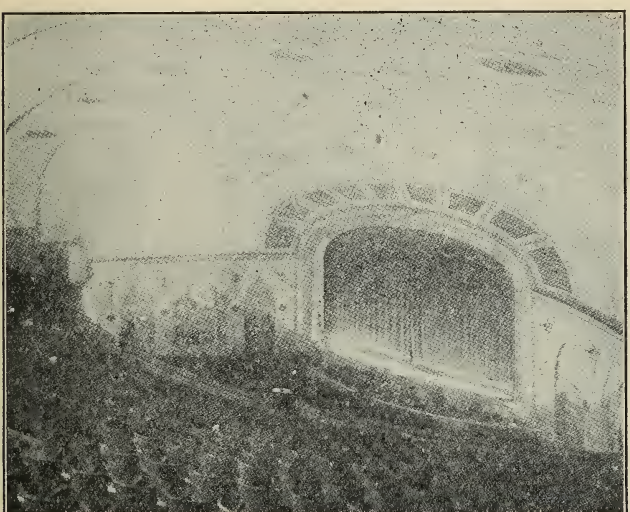


Fig. 95

in any other department of the playhouse. Methods have been devised of recent years, however, that depart very radically from the old time usage. The results produced by the newer schemes are different and far in advance of the ordinary effects, and at a great saving for current. The lighting of the stage is now receiving

more careful thought as to the artistic and economical possibilities. With the newer methods each lamp has its own reflector, thus making possible the most effective use of the light delivered from the lamp.

The losses in control and quantity of light with the old type borders were enormous. The later

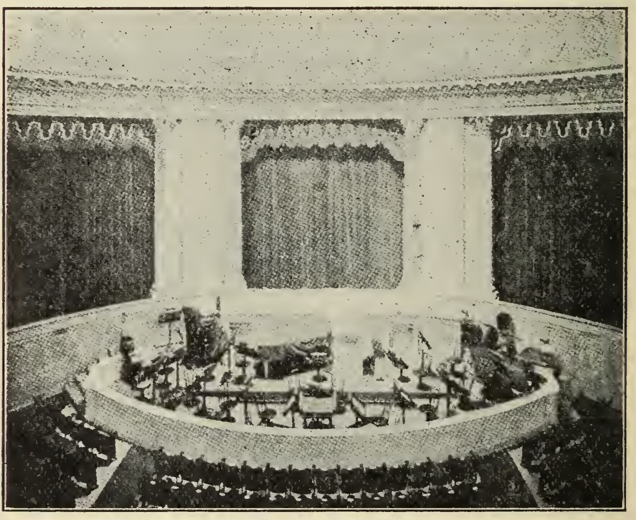


Fig. 96

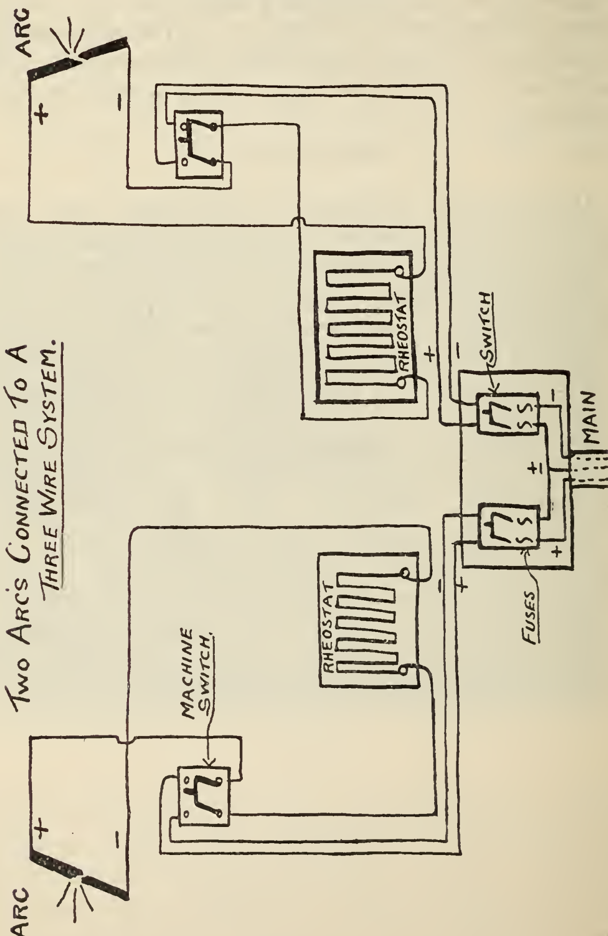
methods have consideration for efficiency in stage lighting. They are scientifically based upon the fundamental principles of light control. The illumination of the stage by direct reflection with its remarkably exact control of light seems to be a step in the right direction as against the old borders whose rays were unconfined.

A type of foot-light of new design is shown in Figure 92 and a border in Figure 94. As will be noted, these types of lighting equipment contain a reflector for each individual lamp, enabling the producer to direct the light where it will be most effective.

CONCLUSION

Illuminating engineers, electricians, and the men who have charge of lighting affairs around the theatre, are playing a part of increasingly greater importance. It is too often the case in the lighting of theatres that the method of illumination is selected after the building is almost completed, with the result that the lighting equipment in no way fits or harmonizes with the other features of the building. It should be kept carefully in mind that the lighting is just as essential as the seats, draperies, etc. The cooperative efforts of the theatre owner, architect, and contractor in making a careful study of the problem along with other details, will be rewarded by most surprising and pleasing results. The effect will be a more suitable, more economical, and more efficient lighting system.

WIRING DIAGRAM FROM MAIN TO ARC LAMPS USING RHEOSTATS



THE INTERIOR ILLUMINATION OF THE MOTION-PICTURE THEATRE

The desirability of providing sufficient illumination for the convenience and comfort of the audience, if this can be accomplished without perceptible loss of quality in the projected picture, is obvious. It is scarcely necessary to enumerate the many serious objections to the use of very dimly lighted rooms in which motion pictures are being exhibited to large audiences. The difficulty encountered by persons entering from the relatively brightly lighted exterior regions in finding their way to unoccupied seats is considerable. The undue strain thrown upon the accommodation processes of the retina resulting from a sudden transition from a brightly lighted exterior to a dark interior, or vice versa, is very objectionable and to be avoided if possible. More serious than these, however, is the excessive visual fatigue and eye-strain resulting from a prolonged observation of a brightly illuminated area (such as the screen on which the picture is being projected) occupying but a small portion of the field of view and surrounded by very dark areas, this condition being ideal for the production of glare effects due to excessive contrasts. It is evident for the satisfactory exhibition of motion pictures that the general illumination in the theatre must be subdued in order that the projected picture shall be of good quality as regards its apparent

brightness and contrast, and that in raising the value of the general room illumination there is a limit beyond which it is impossible to go without seriously affecting these characteristics of the picture. However, it has been found by proper distribution of the light that the general room illumination can be raised to a value sufficient to eliminate all of the objections to a dimly lighted

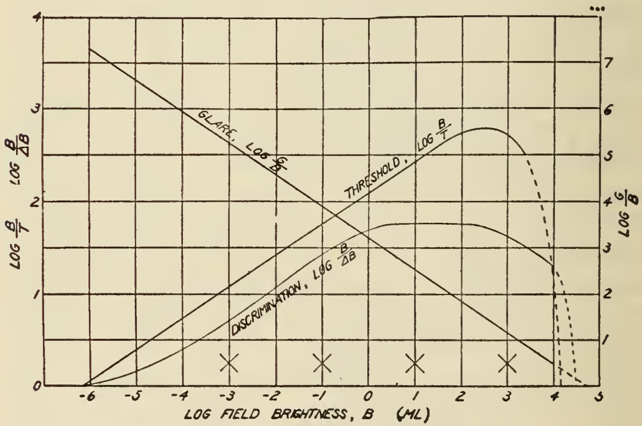


Fig. 97

theatre and at the same time produce no perceptible injurious effect upon the quality of the projected picture.

From a consideration of the fundamental data available relative to the various retinal sensibilities, it is possible to draw certain general conclusions as to the most desirable conditions of illumination for this purpose. The data available, however, are not sufficiently complete to permit

the computation of the desired values, and hence it was necessary to resort to experiment and actually to measure in an experimental installation the illumination which was found to be permissible without causing loss of quality in the projected picture.

Before proceeding with an account of the experimental work, it may be well to consider briefly the general theory of the subject, and the fundamental characteristics of the eye which are important in problems of this nature. First of all, it should be borne in mind that the sensation produced when light falls upon the retina depends upon several factors, such as the intensity of the light, the length of time during which the stimulation continues, wave-length of the radiation, the size and shape of the retinal area stimulated, and the physiological conditions of the retina due to previous action of light upon it. It is sufficient for the present purpose to consider only the reactions of the retina to the intensity factors of the stimulus and neglect those which are functions of its quality.

Of first importance among the factors requiring consideration is the sensibility of the retina to brightness. There are three types of brightness sensibility: (1) threshold sensibility, which is measured by the least brightness perceptible; (2) contrast sensibility, which is measured by the least brightness difference perceptible; and (3) glare sensibility, which is measured by the brightness just sufficient to produce discomfort when observed.

Now the sensibility of the eye to brightness,

contrast, and glare depends upon the condition of the retina at the particular time the determination is made, and that condition is in turn dependent upon the previous stimulation. Hence, it is necessary to specify the condition of the retina at

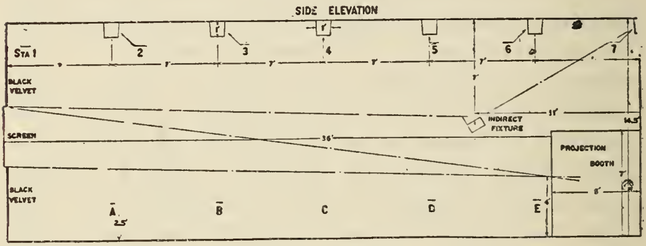


FIG. 98

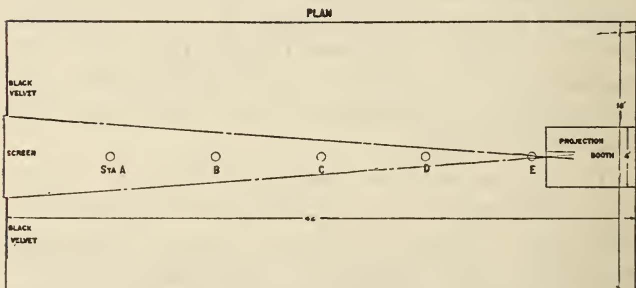


FIG. 99

the time the measurement of sensibility is made. This is done by specifying the brightness to which the eye is adapted, and is termed the "adaptation level" of the retina. For instance, when an observer looks for some time (10 to 30 minutes) at

a uniformly illuminated surface so large as practically to fill the field of vision, a condition of equilibrium in the retinal process is reached, and the observer's eye is said to be adapted to the brightness of the field, and his "adaptation level" is specified by stating the brightness of the illuminated surface, which is sometimes termed the "sensitizing field." It is found that the sensibility of the retina varies over very wide limits depending upon the adaptation level; in fact due to this variable sensibility it is able to operate over a range of brightness from 1 to 100,000,000 (approximately). A complete expression of sensibility therefore requires measurement over the entire adaptation range, and the results are most conveniently expressed in graphic form as curves plotted with values of the various types of sensibility (threshold, contrast, and glare) as ordinates and the adaptation level as abscissae. These three sensibility curves are given in Fig. 97.

Since the variation in value of adaptation level (field brightness) is enormous, it is necessary in plotting the curves to use the logarithms of these values. The ordinates are expressed in units appropriate to the various types of sensibility. For any specified adaptation level, it is now possible to read from the curves the brightness which is just uncomfortable (producing glare), the least perceptible difference in brightness (contrast), and the least perceptible brightness (threshold). Applying this to the case of an observer in a motion-picture theatre, we are able if his adaptation level is known to find to what extent any area may be illuminated without producing glare, to compute the amount of general

illumination which may be tolerated on the screen without producing a perceptible degradation of contrast, or to specify the maximum of brightness difference in the field of vision if undue eye fatigue is to be avoided.

In order to make such useful application of the

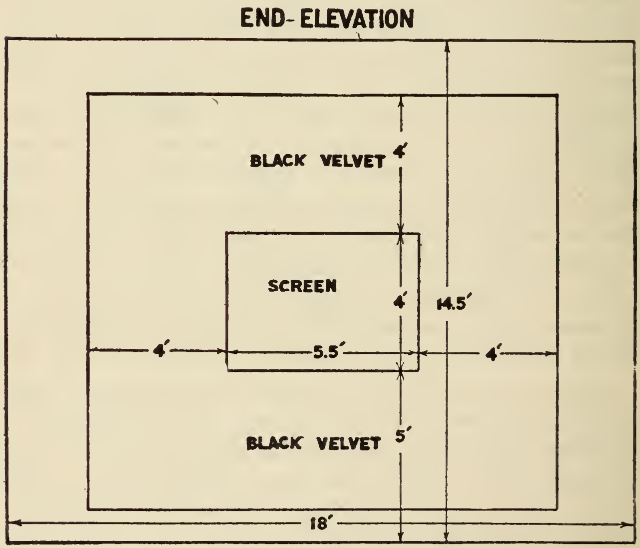


FIG. 100

fundamental data contained in the sensibility curves, it is, however, necessary to know the adaptation level of the observer under the particular conditions considered. Unfortunately the data necessary for this are not at present available. It will be recalled that the "adaptation level" is

defined as specified by the brightness of a uniformly illuminated field filling the entire field of vision, and the retinal sensibilities were determined under such conditions. Now it is probable that the brightness of the foveal image is the most important factor in fixing the adaptation level of the retina, but undoubtedly the brightness of the images outside of the fovea have some influence. In the case of a person watching a motion picture, the picture itself occupies but a relatively small portion of the visual field, and in case the surrounding areas are very low in brightness his adaptation level will probably be somewhat lower than indicated by the average picture brightness. The effective application of the sensibility data, therefore, depends upon a reliable determination of the adaptation level under practical working conditions in the motion-picture theatre. An instrument is at present being developed with which the adaptation level of the retina when stimulated by non-uniform fields may be measured. It is hoped when such measurements are available that the application of the sensibility data will lend additional support to the conclusions reached in the experimental work to be described in the following pages.

In order to make an actual determination of the maximum general illumination permissible, an experimental lighting system was installed in the Projection Room in the Research Laboratory. In designing this system an attempt was made to obtain the maximum average illumination on the table plane (horizontal surface 30 inches above the floor) with a minimum of illumination on the projection screen, and further to distribute

the light so that no area either of wall, ceiling, or lighting fixture should be sufficiently bright to cause glare or appreciable increase in the adaptation level of the observer.

In Fig. 98 is shown a side elevation of the room with the locations of the various elements of interest in this problem and the dimensions of importance. In Fig. 99 is given a plan view and in Fig. 100 an end elevation showing screen with its surrounding frame of black velvet. The ceiling

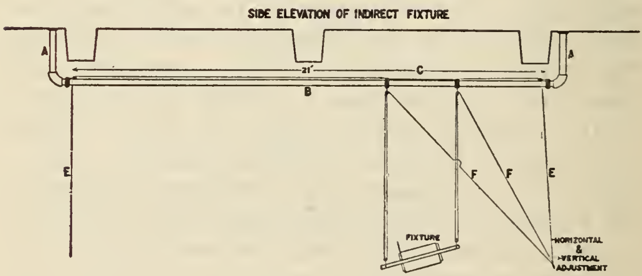


Fig. 101

of this room is painted white, while the walls are a medium tone of buff. The projection screen is of the metallic type, having a high reflecting power for points on and near the axis, but falling off rapidly for angles of greater than 15° from the axis.

The lighting fixture was constructed by mounting six 10 x 12 darkroom ceiling lamps on a light wooden frame work. In order that the position of this fixture could be adjusted to give various

distribution of the light, it was suspended as shown in Fig. 101.

The vertical members *AA* carry the horizontal member *B*, which is a cylindrical metal rod about 21 feet long. One of these fixtures is mounted near each side of the room and parallel to each other. Upon these horizontal ways operate the sliding carriages *C*. Over small pulleys attached to this carriage, the sash cords *FF* operate and suspend the lighting fixture as shown. By means of these adjustments, it is possible to adjust the position of the lighting fixtures to any desired distance from the ceiling, to vary its distance from the projection screen by a considerable amount and further to vary the inclination at which the fixture hangs thus controlling to a great extent the distribution of the light from the fixture.

Complete diffusion of the light from the incandescent lamps mounted in the fixture was obtained by inserting a sheet of 10 x 12 opal glass in the position provided for holding the safelight. This material is of such nature that the light transmitted is very completely diffused. In the projection booth is situated a projection machine of the ordinary type. An arc current of 25 amperes was used throughout the tests recorded in this report. With this current the screen brightness as measured with the machine running but without a picture in position was found to be approximately 20 milli-lamberts. This measurement was made from a point very near to the axis of projection and due to the character of the screen was much higher than the brightness measurement made from points a few degrees from

the axis. From measurements made previously in several of the motion-picture theatres in Rochester, an average value of screen brightness under similar conditions was found to be approximately 15 milli-lamberts. The screen brightness used in these experiments therefore is somewhat higher than is ordinarily met with in practice.

The lighting fixtures having been installed, the procedure followed was to determine by trial and error the maximum amount of light which it was possible to use without causing an appreciable

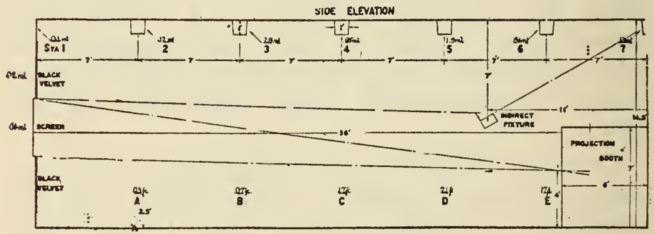


FIG. 102

loss of quality in the picture. After several preliminary trials it was decided that the best result was obtained by placing 60-watt lamps in the four central elements of the fixture and 40-watt lamps in each of the end boxes, the entire 10 x 12 surface of the diffusing glass being uncovered and used as effective source area. The position of the fixture which was found to give a very satisfactory distribution of the light was as indicated in Fig. 107. This position was approximately five feet from the ceiling and eleven feet from the rear wall

of the room, and with the fixture inclined forward so as to give an evenly graduated distribution of the light on the ceiling. It was found necessary in order to prevent excessive illumination of the screen by the light from the fixture to place a cardboard screen along the front of the frame carrying the safelight fixtures. This was of such dimensions that no direct light from the opal glass was permitted to fall upon the projection screen, and served also to reflect some of the light backward, so that the ceiling brightness at the

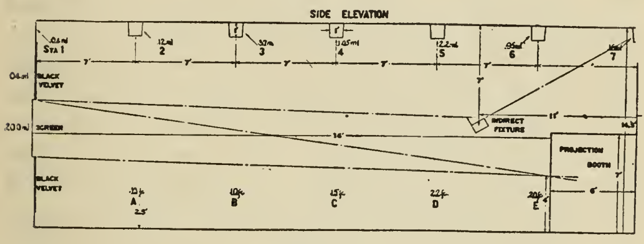


FIG. 103

rear of the room was brought up to a value more nearly equal to that of the brightness of the ceiling directly above the fixture.

This arrangement having been arrived at and considered satisfactory, several experienced observers were asked to express opinions as to whether or not the quality of the projected picture was seriously affected by the presence of this general room illumination.

By observing the screen with the eyes so shielded that nothing but the picture could be seen, the ceiling lights were alternately turned

off and on, and the effect upon the quality of the picture observed. While it is possible to detect a slight veiling of the deeper shadows when the room illumination is being used, the effect is so slight as to be inappreciable in causing a degradation of the contrast of the picture.

Undoubtedly the veiling illumination falling upon the screen from the general illumination in the room is sufficient to cause an easily measurable decrease in actual contrast of the picture. Actual observation, however, shows that this decrease in contrast is not apparent to the observer. The explanation of why this decrease in contrast produces such a small apparent effect is of considerable interest, and is, in fact, of fundamental importance. The explanation lies in the fact that the contrast sensibility of the retina increases as the adaptation level rises. The presence of the general room illumination is responsible for a rise in the adaptation level of the observer, and the corresponding increase in contrast sensibility permits the perception of smaller brightness differences. If in the projected picture a constant contrast has been maintained, this increase in contrast sensibility would tend to make the picture look more contrasty, but since the presence of veiling glare tends to decrease the actual contrast, the two effects work in opposite directions and tend to compensate each other, the result being no perceptible change in apparent contrast.

On the whole this arrangement was considered very satisfactory by all those observing. One point of interest noted was that much less visual discomfort resulted when the screen brightness

was suddenly changed by the appearance of the title region of the film, and further that a slight residual flicker due to lack of precise shutter adjustment was less noticeable. In fact much less general eye fatigue resulted when the room lights were on than when they were turned off.

In order then that a permanent record of the quantity and distribution of illumination used might be obtained, a series of brightness and illumination measurements were made. For this purpose the Macbeth illuminometer properly calibrated was used. The points at which measurements were made are indicated in Fig. 98. The stations *A*, *B*, *C*, *D*, and *E*, represent points on the table plane, that is, 30 inches from the floor, while the stations, 1, 2, 3, 4, 5, 6, and 7 are situated at various points on the ceiling as indicated by the arrows and represent the points of maximum brightness as seen by an observer situated at a point near station *D*. All values of brightness are expressed in milli-lamberts (m. l.) and those of illumination in foot candles (f. c.). In order that a complete analysis of the distribution of the light might be made, sets of measurements were made under four conditions of illuminations as follows:

I. Ceiling lights on. Arc not operating.
II. Ceiling lights on and arc operating. No picture in the machine.
III. Arc operating, no picture, no ceiling lights.
IV. Ceiling lights and arc with picture.

The measurements obtained under I. indicate the intensity and distribution of the light from the installed fixture. The data in III. represent

the intensities and distribution of the light reflected from the screen when the arc is operating but with no picture in the machine. The data in IV. are of greatest interest, as they represent the distribution and intensity of the illumination under actual operating conditions, the sources of light being both the installed fixture and the light reflected from the projection screen. The data in II. were recorded as being of interest in indicating the difference between the illumina-

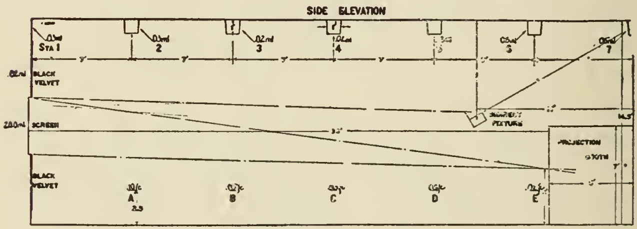


Fig. 104

tion with and without a picture in the projecting machine.

The measurements having been completed with this arrangement of the lighting fixture, it was decided to make a second adjustment and to repeat the measurements with slightly changed conditions. The distance between the fixture and ceiling was increased to 7 feet, and the inclination changed somewhat so that while the projection screen was protected from direct light a higher ceiling brightness near the front of the room was obtained. The photometric measurements were then repeated from the same set of

groupings as employed previously. The data on the two arrangements of the lighting system are recorded in Table I. A detailed consideration of this table will not be given at this time.

In order to present this data in more graphic form, the values of brightness and illumination are written in at the proper position on prints showing the side elevation of the room, and a brief consideration of these will be taken up. The conditions obtained with the second arrangement of the fixture were somewhat more satisfactory than the former, hence our attention will be confined entirely to the values obtained with this more favorable arrangement.

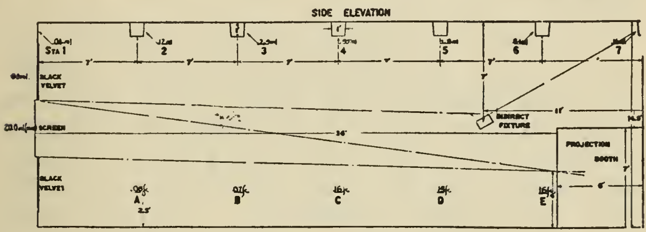


FIG. 105

In Fig. 102 the data obtained with the ceiling lights on but without the projection arc are shown. It will be noted that the maximum ceiling brightness is obtained slightly in front of the fixture, the maximum being 1.9 ml. This brightness decreases gradually toward the front of the projection room. The illumination on the table plane due to this source is indicated by the figures at stations *A*, *B*, *C*, *D*, and *E*.

In Fig. 103 brightness and illumination values at corresponding stations are shown, the condition being that ceiling lights were on and the projection machine operating but without a picture in the machine. A comparison of these values with those in the previous figure shows the magnitude of the illumination resulting from the light reflected from the projection screen, its influence being most marked near the front of the room. This is more clearly shown by Fig. 104, in which the measurements of illumination due to the light reflected from the projection screen alone are indicated.

The data of greatest interest, however, are shown in Fig. 105, these being the values obtained by taking measurements under actual operating conditions, that is, with the projection machine operated in the usual way with a picture of normal density and the lights providing the general room illumination turned on. It will be noted that the ceiling brightness is relatively high near the rear of the room, its maximum being 1.8 ml. This brightness decreases to a value of .04 ml. directly above the projection screen. The illumination on the table plane is also high at the rear of the room at a maximum value of .19 f. c. and a minimum value of .06 near the front.

This arrangement of the room illumination was found to be entirely satisfactory from the standpoint of the picture quality. No appreciable diminution in the apparent contrast or brightness of the picture was perceptible. With this illumination it is quite possible after becoming accommodated to the existing brightness level to read with comfort ordinary newspaper print, and fur-

thermore the length of time required for accommodation is very short. For instance, an observer entering the room with eyes adapted to full exterior daylight levels can see immediately every detail of furniture in the room and a period of not more than one or two minutes is necessary for adaptation sufficient to read with ease ordinary printed material.

The general conclusions to be drawn from these experiments are that a relatively large amount of general illumination may exist in motion-picture theatres without appreciably affecting the quality of the projected picture, provided that this illumination is properly distributed.

In Fig. 106 is shown a possible arrangement of the lighting system which would give a highly satisfactory theatre illumination. This plan is presented as illustrative of one way of handling the problem and undoubtedly many others may be worked out.

The ceiling which consists of four arches or concavely curved surfaces is illuminated by lamps inclosed in the fixtures, which are designed to appear as integral parts of the beam structure, as indicated. The intensity of the various lights is distributed roughly as indicated by the numbers i = ix, i = 4x, etc. This would result in a relatively high ceiling brightness at the rear of the theatre and a relatively low value at the front. Since the lamps themselves must be placed comparatively close to the ceiling, it would be necessary in order to obtain an approximately uniformly graded ceiling brightness to arrange the decorative scheme applied to the ceiling so that the regions marked *B* should have a relatively

low reflecting power, while those marked A, on the other hand, would have a very high reflective power. The details of some such decorative systems have been worked out, but they will not be considered at this time. The lighting of the ceiling underneath the gallery is obtained from lamps at B and here again the ceiling reflecting power should vary from a low value at B to a high value at A.

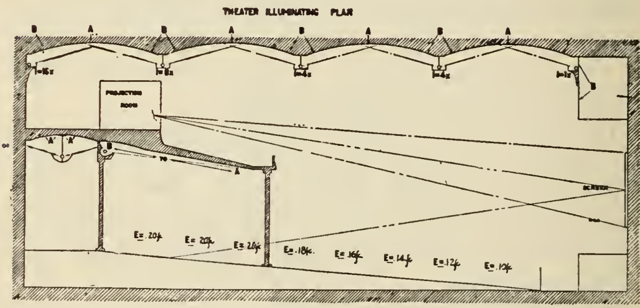


FIG. 106

From the result of the experiments in the projection room, it has been concluded that the illumination on the table plane at various points in the theatre should be approximately as indicated by the values of E, and the number and size of the light units used should be so adjusted as to give the indicated values. While an approximate computation could be made indicating the number and size of units necessary, it would be quite impossible without detailed information of the dimensions of the room, the reflecting power of various surfaces, and the exact positions of the

lamps to make a definite estimate as to the total quantity of light flux necessary.

In Fig 107 are shown three cross-sectional diagrams illustrating the possibilities in beam design which would result in the proper distribution of the light flux over the ceiling. These designs, of course, are only given as suggestions of what might be done in arranging an indirect system of illumination conforming with the conditions outlined in this report. The beam structure adopted in any particular case will be influenced to a great extent by the architectural style of the theatre and the diagram given serves only to suggest a method of concealing the lamp within the beam structure and at the same time obtaining the proper illumination of the ceiling.

It should be mentioned also that the illumination in the lobby and in the various vestibules and extreme rear of the theatre should be so arranged that a person entering the theatre passes gradually from the illumination of the exterior to that of the body of the theatre. That is, the transition from exterior brightness level to the interior brightness level should be made in a series of gradual steps rather than in a single abrupt step.

Returning again to a consideration of the brightness of the frame surrounding a picture, it was found by experiment that raising the brightness of the frame to a value of approximately .02 m. l. gave a much more pleasing effect than when the black velvet frame was used, in which case the brightness was so low as to be beyond the limit of measurement with the instrument available. The contrast between the frame and the highlight of the projected picture, which is estimated to

have been about 1 to 10,000 in case of the black velvet frame, was found to give rise to a certain feeling of visual fatigue and discomfort. By covering the velvet with a draping of white mill net the reflecting power was increased to such an extent that the contrast between the frame and picture was considerably reduced. It will be noted

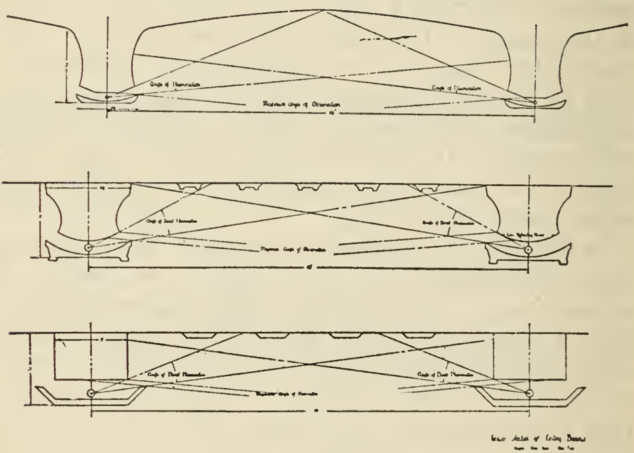


Fig. 107

that the average screen brightness without any picture in the screen is found to be 20 m. l. The average screen brightness with a normal film in position is probably of the order of 2 m. l., while the maximum may be taken to be somewhere in the neighborhood of 10 m. l. With a frame brightness of from .02 to .03, as indicated by the data, the maximum contrast between picture and frame is reduced to less than 1 to 1000, while the average contrast is approximately 1 to

100. Now the sensitometric data on glare indicate that with the eye adapted to ordinary daylight levels a contrast of over 1 to 100 results in glare or undue fatigue. However, with the eye adapted to lower levels, the allowable contrast increases to a considerable extent and if (See Fig. 97) we assume an adaptation level of 1 m. l., the data indicate that contrast as great as 1 to 1000 may occur in the visual field without resulting in glare or undue visual discomfort. Contrast greater than this, however, should not be permitted. These results indicate that in general a black frame should not be used, but that a much more pleasing and less fatiguing arrangement will be obtained by the use of the frame of somewhat higher reflecting power.

The general conclusions are, therefore, as follows:

By proper distribution of the light, the general illumination of the interior of a motion picture theatre may be raised to a considerable extent above the values in common use without causing any appreciable loss of quality in the projected picture. The illumination on the table plane in fact may be raised to the point where ordinary news print can be read with ease by an eye adapted to the existing brightness level.

While it is impossible to outline specific instructions for particular cases without detailed knowledge of such factors as dimensions and architectural details of the room, the reflecting power of the various ceiling and wall surfaces, and the position of the light fixtures, the following general principles may be outlined:

(1) The illumination on the table plane should

vary from .10 foot candles at the front of the theatre to .20 foot candles at the rear.

(2) No area (outside of the projected picture) visible from any seat in the theatre should have a brightness of more than 2.5 to 3.0 m. l.

(3) The attainment of (1) without exceeding the values mentioned in (2) requires the use of very extended effective sources such as illuminated ceiling and walls and is best accomplished by the use of an indirect system of lighting.

(4) All light sources and fixtures such as diffusing globes and translucent glass ware having a surface brightness of more than 2.5 to 3.0 apparent milli-lamberts should be entirely concealed from view.

(5) It should be noted that a sheet of white paper illuminated by a 25-watt lamp at a distance of 12 inches has an approximate brightness of 20 milli-lamberts. A sheet of music, therefore, illuminated in this way if visible becomes a glare spot and may cause great discomfort to the audience. Arrangements should therefore be made which, while providing adequate illumination for the musicians in the orchestra, will prevent the illuminated music sheets from being visible to the audience.

(6) The contrast between the highest light of the picture and the surrounding frame should be less than 1 to 1000, preferably less than 1 to 500. Black frames should therefore be avoided, one of a neutral gray being much preferable.

(7) Lighting of lobbies, vestibules, etc., should be so arranged that the transition from the brightness level of the exterior to that of the interior,

or vice versa, is accomplished by a series of small differences rather than by a single large one. Such arrangement will to a great extent eliminate the visual shock which accompanies a sudden change in the intensity of the visual stimulus.

(8) The use of a projection screen set well back on the stage and thus shielded to a great extent from the light reflected from ceiling and walls would probably permit the use of even greater room illumination than was used in these experiments.

TABLE

		Ceiling Brightness							Illumination on Table Plane, Screen and Frame						
		1	2	3	4	5	6	7	A	B	C	D	E	S	F
I.	A	.02	.05	.14	.84	2.7	1.2	1.4	.02	.05	.10	.15	.19	.02	.01
II.	A	.03	.07	.14	.84	2.6	1.3	.18	.15	.09	.15	.15	.17	20.00	.03
III.	A	.03	.03	.02	.02	.03	.06	.05	.10	.05	.03	.03	.03	20.00	.02
IV.	A	.02	.04	.14	.84	2.3	1.3	.15	.04	.04	.13	.15	.19	10.00	.02
I.	B	.04	.12	.28	.95	1.9	.84	.15	.03	.07	.17	.21	.17	.04	.02
II.	B	.04	.12	.37	1.05	2.2	.95	.16	.13	.10	.15	.22	.20	20.00	.04
III.	B	.03	.03	.02	.02	.03	.06	.05	.10	.05	.03	.02	.02	20.00	.02
IV.	B	.04	.12	.29	.95	1.8	.84	16	.06	.07	.16	.19	.16	10.00	.03

I. Ceiling Lights On, Arc Not Operating.
II. Ceiling Lights On, Arc Operating. No Picture.
III. Ceiling Lights Off. Arc Operating, No Picture.
IV. Ceiling Lights On, Arc. Picture on Screen.

THEATRE WIRING

It is unnecessary in this article to emphasize the importance of carefully planning the installation of the electrical system in a theatre. While the author will touch on the various general details of the subject, it is beyond the scope of this book to give a complete technical treatise on so broad a subject. It is, however, well to remember that in nearly every theatre project, additional circuits are required after the theatre is completed, either between the booth and the stage, or between the stage and the auditorium, so that it is always good economy and forethought to provide empty conduits and as many of them as the money appropriation will permit.

It is a well known fact that due to the rapid development of the incandescent lamp which at one time was Carbon and later on Tungsten and now Nitrogen Mazda, the demand for larger and brighter lamps and increased illumination is constantly being planned not only in existing theatres but also in new ones. For this reason alone, it is advisable to plan the electrical installation with feeders having capacity of at least 30 per cent greater than required and the branch circuits to have no more than 12 receptacles or more than 600 watts dependent upon one cutout (excepting footlights, borders, or coves). It is true that the Underwriters will permit 660 watts on an ordinary circuit and 1320 on the special circuits but the recommendation given above is based on experience which has always proved that the

lighting demand is always increased when the theatre begins operating.

Wiring should be installed in rigid conduit throughout and not BX cable. With this arrangement it is possible to withdraw defective wires and pull in new ones should the necessity demand it.

Included in the wiring equipment of a theatre should be suitable hangers for the various fixtures, particularly the auditorium fixtures which, if out of reach, should be provided with a suitable type of winch and lowering device.

In many localities throughout the country the Underwriters' rules will not permit wire smaller than No. 12 B & S gauge to be used for lighting circuits, while in other localities permission may be obtained to use wire as small as No. 14 B & S for circuits in front of the curtain line but nothing smaller than No. 12 B & S gauge in back of the curtain line. The conduit work in the house portion of a theatre should be run concealed and that on the stage portion may be run exposed.

LIGHTING EFFECTS

Experience and popular approval has shown that high class lighting effects on the stage as well as in the auditorium are absolutely necessary. These effects should be provided not only where legitimate shows are produced but also in the moving picture theatre and in the vaudeville house.

By the use of suitable dimmers, various color schemes are obtained which harmonize with scenes shown on the screen or on the stage and ofttimes synchronize with the musical program.

It is also desirable to "gradually" increase the brilliancy of the house lights rather than to throw them on abruptly after a long period of darkness.

HOUSE LIGHTING

Including the front of the theatre, auditorium, lobbies, foyers, rest rooms and in general all lighting in front of the curtain line, there are many systems in vogue. The old style of direct lighting from elaborate fixtures is becoming practically obsolete. The three recognized systems of lighting designed for the modern theatre are respectively, direct, semi-indirect and indirect.

The "direct" system, which is the oldest, usually gives deep shadows, hard contrasts and uncomfortable glaring in the eyes of the audience. Its only advantage is that it is slightly more economical in current consumption than the other systems.

The "semi-indirect" system projects the greatest volume of light against the ceilings and walls, which is in turn reflected into the auditorium. Some of the illumination passes through translucent glass panels in the bottoms and sides of the fixtures and sort of helps to smooth out the deep shadows.

In the total "indirect" system the light is projected against the ceilings or walls only, and is then reflected into the illuminated area. This results in filling the illuminated space with a soft, diffusing, warm glow absent of all glaring effects, and lamps concealed entirely from view.

The most successful lighting schemes are those using a combination of semi-indirect and indirect lighting thereby making it possible to obtain beautiful effects.

In the indirect system, cove lighting is used extensively. The lamps are concealed behind ornamental plaster coves backed up either with a suitable reflector or else the plaster work is so formed as to form a mathematical reflector itself. This type of lighting will show off to best advantage the ornamentation, decorative treatment, draperies and fixtures. The color of the lamps is a matter of individual experiment. It may be found instead of using clear lamps that half amber and half white lighting will be more effective and softer. For stairway emergency lighting and exit lighting, the Code of Ordinances enforced by the local inspection bureaus must be followed carefully.

OUTSIDE ILLUMINATION

In arranging the feeders and circuits for illuminating the front of the theatre, careful consideration should be given to current capacities. Here again it is advisable to provide at least 30 per cent more capacity in the feeders than is required, on account of the constant changing in the types of lamps being developed by the large manufacturing concerns and which are invariably used for contrasting certain reading matter, particularly if the location of the theatre is on a brightly illuminated thoroughfare.

STAGE LIGHTING

Lights in back of the curtain line are all controlled with the exception of the dressing rooms, from the stage switchboard. This switchboard should receive very careful planning and consid-

eration and all the details which go into making up the switchboard should be referred to an expert since the success of the theatre either as a legitimate house or as a moving picture house, depends almost entirely on this equipment.

The various lamp outlets in back of the curtain line should be equipped with a steel outlet box, a suitable lamp receptacle provided with a wire lamp guard which is riveted to the cover of the outlet box and a locked cover to prevent theft of the lamps.

INCOMING SERVICE

If the theatre is located in a district where direct current is obtainable, then two feeders should be installed for supplying the stage switchboard, one to act as a breakdown for the other.

In addition, a direct current feeder is run to the projection booth for supplying the projection machines and spotlights. In districts supplied by alternating current, two services should be installed and in addition, if possible, a direct current service should be obtained for supplying the projection room only. With this arrangement an alternating current feeder should be run to the projection room which will run a motor generator set. The motor generator set may act as a breakdown for the direct current service and may be of limited capacity.

STAGE SWITCHBOARD

This should always be of the "dead front" type, preferably arranged for a "Preset Interlocking" arrangement.

This switchboard should be

1. Designed to control the lights on the stage and in the auditorium.

2. Should have sufficient number of switches to properly connect and disconnect lights to be controlled.

3. To be positive and simple in operation and construction.

4. To have no live electrical parts exposed to operator or persons who might accidentally come in contact with them.

5. To have all fuses or parts which may require replacement from time to time easily and quickly accessible to the operator without leaving the immediate vicinity of the board.

6. To have the different switches and their operation systematically grouped and their control so arranged so that it will not be radically different from switchboards previously installed, so that any experienced stage electrician can quickly learn their operation.

7. To be compact so as to require a minimum amount of space.

8. To have all parts standardized so that the cost of replacements will be reduced to a minimum.

9. The switchboard should represent a type which has been in actual operation for not less than five years so that its practicability and durability is a known quantity.

10. Should preferably be of the "present type" arranged so that the lever mechanisms on the front of the board can be set at least one or two scenes ahead without interfering with the scene in progress, so that one man can operate the

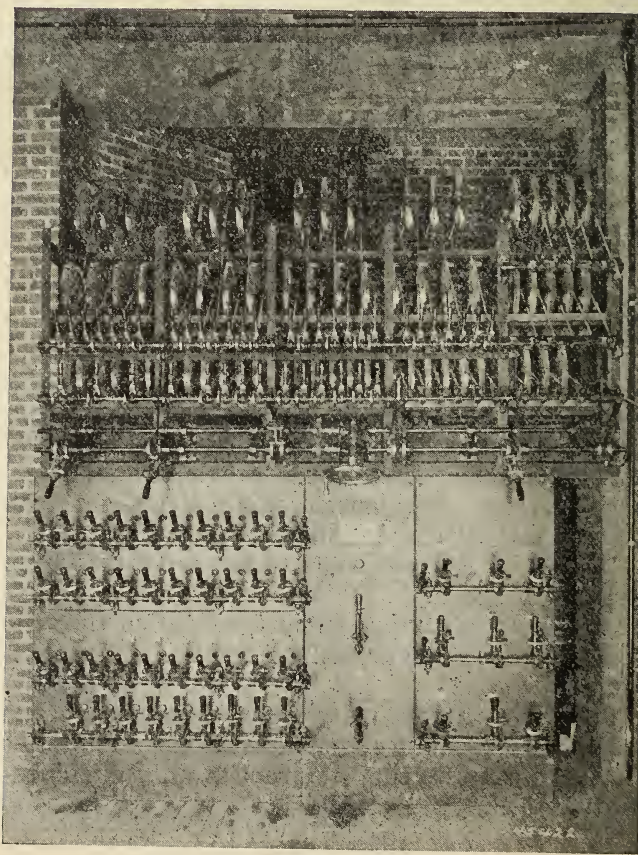


FIG. 108

switchboard and dimmers and have sufficient time to supervise other electrical apparatus on the stage. Such a type of board is shown in Figure 108.

11. Switches thereon should have no less than 100 amperes capacity even though the feeder they supply is considerably less than this.

12. Switches should be of the double break type so that all parts except those directly connected to the bus bars are dead when the switch is open.

13. Fuses should be dead when the switches are open and readily accessible.

14. Interlocking mechanism should be arranged so that any one of the switch levers may be used as a master lever.

15. By referring to Figure 109, it will be noted that the "preset-lever" can be placed in the following positions:

(a) "Off." When the preset lever is in the position marked "off," the master lever will throw the switch "off" but will not throw it "on."

(b) "On." When the preset lever is in the "on" position, the master lever will throw the switch "on" but will not throw it "off."

(c) "Pos." (positive.) When the preset lever is over the position marked "Pos." the switch is interlocked with the master lever and will move with every operation of the master lever.

(d) "Ind." (independent.) When the preset lever is over this position, the switch is independent of the shaft and of the master lever and in this position the switch may be operated individually.

The preset levers should be easily manipulated to be moved into the notch over the position desired by a slight pressure of the finger.

Switches are to be arranged so that they can be operated singly or in groups for the different colors as required. Each switch should be provided with an indicating pilot light adjacent to the switch with colored lenses to correspond with the lights which they control and shall indicate when the switch is "on" and go dark when the switch is "off."

The wiring up to the board shall be enclosed in a steel trough running between the switchboard and the magazine panel which is usually placed directly in the rear of the switchboard. All wires running from the trough to the connections on the switchboard should be encased in asbestos tubing.

In designing a switchboard it is advisable to make up a schedule as shown in Figure 110 on which should be indicated the capacities required for the various switches, fuses and dimmers and also show which switches are to have master control and which are to have slow motion grand master control.

Suitable pilot lights shall be provided on the switchboard for illuminating the front and rear which should be independent of any of the circuits.

The switchboard should be built in three sections, namely, one section for house switches, one section for main switches and stage pockets and one section for stage switches.

Switches should be arranged in three tiers and should have corresponding color switches in vertical tandem with each other.

The slow motion dimmer wheel shall project over the center section.

The magazine panel should be mounted on the wall back of the switchboard and enclosed in a sheet steel cabinet with heavy spring hinges and latch. This panel does not require branch switches but it must have a fused section for each branch circuit for all the auditorium and stage lights as listed in schedule.

DIMMERS

Over the stage switchboard there shall be set on a strong angle iron frame the dimmers as listed in the schedule, which should be connected to the switchboard. Each plate should be equipped with not less than 100 steps, and should be connected together in gangs for master and single control. The gangs should be equipped with handles for each dimmer, a master handle for each color for stage control, a master handle for each color for house control and a grand master slow motion wheel for the entire equipment.

Dimmers should be arranged so that any single plate can be operated alone or so that all plates may be operated in a single row or that any row may be interlocked and operated by a grand master cross interlocking wheel drive. All dimmer handles should be colored and marked so that color of circuits can be easily determined.

Dimmers should be designed so that the lights may be operated from "full bright" to "dark out" and all dimmers used for auditorium lighting should be rated for continuous duty.

PROSCENIUM STRIPS

Proscenium strip reflectors should be installed on each side of proscenium arch when required and concealed from the view of the audience. Each strip should preferably contain 6 white, 6 red, and 6 blue 150-watt receptacles wired alternately and built of no less than No. 20 gauge galvanized iron, painted three coats of flat white fireproof paint on reflecting surfaces.

BORDER LIGHTS

The number of border lights varies from one to four and is determined by each special condition. The front borders, one of which is usually known as the concert border, should be from 25 to 40 feet long, approximately 2 feet longer than the proscenium opening, and to be wired and equipped for approximately 40-75 watt whites, 40-60 watt reds and 40-60 watt blues. (Colored nitrogen Mazda lamps are not serviceable.)

The number of borders required will be governed by the size of the stage, but they should in any event be not more than 6 feet apart.

The concert border is usually installed on the soffit of the proscenium arch between the valance and asbestos curtain and should be concealed from public observation. The other borders can be longer but wired for approximately the same number of lamps.

The wiring for the borders should be carried straight across the strips from end to end. A suitable junction box with a slide cover should be

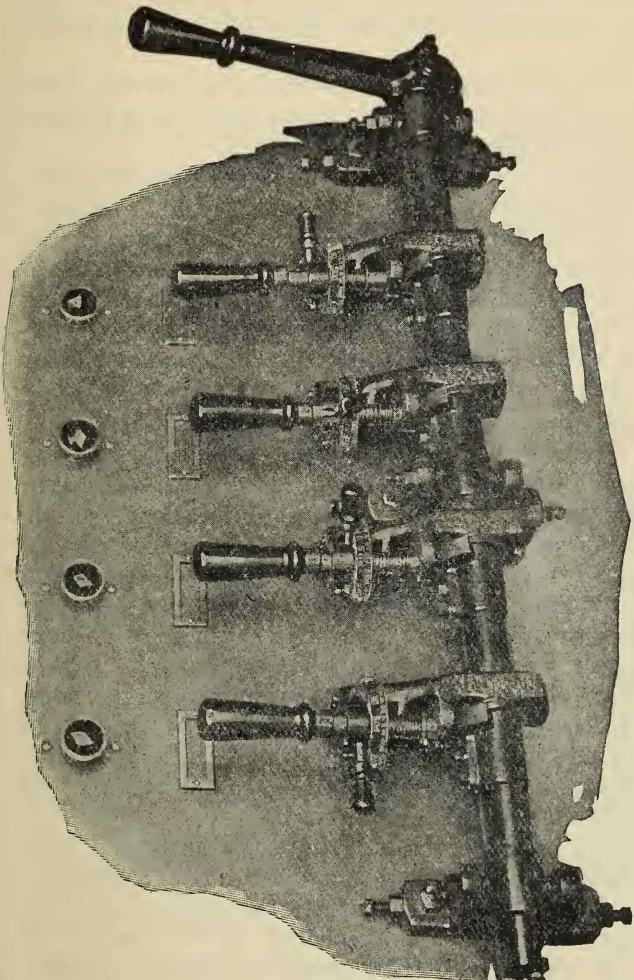


FIG. 109

provided at the end of each strip for bunching and connecting the ends of the strips to the border cable.

The reflectors should be made of not less than 20-gauge galvanized iron and painted in a similar manner to the proscenium strips.

Each of the border light strips should be securely braced and provided with suitable hangers to make them firm and rigid. On one of the borders it is customary to equip at least four receptacles for 75-watt lights evenly spaced along its full length and to be controlled from a separate switch on the switchboard to be used for working lights.

BORDER LIGHT CABLES

Each border should be equipped with a lighting cable containing the required number of flexible conductors and two spares. The cables should be run in conduit from the stage switchboard to the gridiron, where they may be terminated in an elbow or suitable fitting. The cable shall be long enough to extend from the gridiron to within 5 feet of the stage floor without disconnecting and the weight of the cable shall be supported by a suitable crib which will raise the loop high enough above the proscenium arch so that it will not be visible to the audience.

Each border light strip must be arranged with suitable rigging and counterweights and particular attention must be paid to the enclosing of the counterweights so that people on the stage will not be exposed to the danger of falling weights.

Necessary connection boxes with connection terminals should be installed in the gridiron for

connecting the borders to the circuit wiring after they have been hung.

FOOTLIGHTS

Footlights should consist of a special form of heavy sheet iron gutter reflector built into a trough in the platform apron. The entire reflector should be rolled in one piece and the hood must be arranged so that it will thoroughly conceal the lamps from public observation.

The trough must be designed so that the lamps flood the stage with light and form no dark or shady spots on the floor.

The hood must be rigid enough to withstand any mechanical injury and must sustain the weight of any person standing on top of it.

The lamp receptacles to be wired alternately for each color so that the circuits will extend entirely across the trough from one end to the other. Each receptacle must be thoroughly enclosed with sheet iron with no exposed porcelain.

The wiring must be No. 12 and at one end of the trough a junction box should be installed to facilitate the connection of the wiring. From this point the wiring is installed in conduit to the magazine panel and stage switchboard. It is customary in large theatres to arrange a footlight trough with a double row of receptacles, the front row for white and the back row for color, arranged alternately.

A footlight trough 40 feet long usually contains 50-75 watt whites, 50-60 watt reds and 50-60 watt blues. It is important when mounting receptacles

in a trough of this kind to keep the filament of the lamps on line with the stage floor.

MUSICIANS' OUTLETS

A suitable number of outlets to be installed in the musicians' pit, each to consist of an outlet box and cover through which a special stage cable and 2-piece fibre connector is attached. These outlets are to be controlled from the stage switchboard. Where pretentious musical programs are intended, as many as 30 or 40 of these outlets should also be installed on the stage itself.

STAGE POCKETS

Bunch lights, spots, olivettes, floods, brackets and similar special lights are usually plugged into stage pockets. They should usually be at right and left of the stage and at the rear center a 3-section stage pocket, three of the sections wired for incandescent circuits and one for an arc circuit. One double arc pocket can be placed at each side of the proscenium bridge and also two to four arc pockets for both sides of the fly gallery. Sufficient lights should also be placed under the fly gallery to light the stage for working purposes as well as lights placed on both sides of the fly floors and above the grids. In the center of the grids a wall type pocket should be placed, controlled from the stage switchboard through dimmers. This is used usually for chandeliers or other fixtures which may be hung over a stage set.

Stage pockets should be of an approved type suitable for incandescent and arc lights as called

for in the schedule. As many pockets as practicable should be arranged for red incandescent, blue incandescent and white incandescent and a few pockets arranged for arcs. About 50 per cent of the incandescent pockets should be connected through the dimmers and from each pocket circuits shall run to the magazine panel. Incandescent pockets shall have a minimum capacity of 25 amperes and arc pockets 100 amperes.

ORGAN EQUIPMENT

Where an organ is contemplated 3-inch empty conduits should be run between the organ console and each organ loft and a 1½-inch conduit between the organ console and the organ generator. Suitable feeders should also be run from the main switchboard at the service to the organ blower room for supplying the organ motor and various ventilating equipment.

It is customary to install remote control automatic switches so that the organist may start and stop the organ motor from the console and where this is required empty conduits should be provided. It is also customary to install a conduit from the console to the projection room to contain circuits for operating signal lamps which either the projectionist or the stage electrician may operate.

TELEPHONES

A complete system of intercommunicating telephones should be installed between the manager's office, stage switchboard, orchestra foyer, orchestra leader, projection room, boiler room, musicians' room in basement, ticket booth in vestibule. The

telephones in the musicians' pit and in the projecting room should be of the portable head set type. The others may be of the wall type. The cable for the musicians' telephone should be long enough to extend to the pianist or orchestra leader. The cable for the projecting room should be long enough to extend to the operator while operating his machine.

ANNOUNCEMENT FRAMES

Where necessary, announcement frames should be installed on each side of the proscenium arch and these are to be controlled from the switchboard.

BELL SYSTEM

Push buttons should be located at stage switchboard to ring a bell in each dressing room, a bell in the musicians' room, a bell in the projection room and a bell at the main switchboard in basement.

Push buttons located in the projection room should ring a buzzer at the stage switchboard and one at the orchestra leader's stand.

Push buttons located at the orchestra leader's stand should ring a buzzer at the stage switchboard and in the projection room.

PROJECTION ROOM EQUIPMENT

This should be carefully planned and you are referred to other sections in this book where complete discussions are given regarding various arrangements.

COVE LIGHTING

Cove lighting shall consist of approved reflector strip built of no less than 20 gauge galvanized iron

painted in a similar manner to the border lights. This strip shall extend along the full length of the cornices and contain the necessary receptacles as required.

Cove lighting may be used to good advantage at the following locations:

Main dome cove.
Mezzanine promenade cove.
Mezzanine well cove.
Smoking room cove.
Lobby cove.

ILLUMINATED PANELS

It is customary to install translucent panels in the soffits of the balcony and in locations where they will work in well with the ornamental treatment of the interior and at these points recesses shall be left in which suitable pans can be installed made of 20-gauge metal containing the proper number of receptacles for color lighting.

FAN OUTLETS

These should be located on the various walls and columns of the auditorium and should be controlled from the stage switchboard.

INTERIOR EXIT LIGHTS

At each of the exit outlets in front of the curtain line, a galvanized iron tray shall be installed measuring approximately 24 x 10 x 5″. The opening must be flush with the face of the wall or plaster. The conduits shall terminate in the receptacles which shall be installed in approved outlet boxes. The lettered glass covers of these exit boxes can be designed by the architect and may

be as elaborate as conditions will permit, but local inspection laws bust be observed in so far as the size of the letters is concerned.

EXTERIOR EXIT LIGHTS

At each one of these locations a weatherproof outlet box shall be installed, equipped with a weatherproof receptacle and heavy marine type wire guard.

All the wiring for the outside exit lights must be run entirely independent and separately from the interior exit lights and in a separate conduit.

The exit lights are supplied by a feeder which is independent of anything else in the building.

EMERGENCY LIGHTING

A Usem Emergency Lighting System for a theatre, or other public building, comprises a separate circuit supplying lamps in all the exit lanterns and also a sufficient number of lights placed around the auditorium, foyer, dressing rooms, etc. These lamps are independent of the main lighting circuits and, in order that they may be truly reliable in emergencies, they are supplied from a source of electrical energy entirely separate from that used at normal times. Also it is essential that their lighting circuit should be thrown on *automatically* when the primary lights fail. Dependence upon the unreliable human element for turning on the reserve supply is entirely eliminated.

The *Usem System* actually accomplishes what the methods heretofore employed have failed to accomplish by connecting the Emergency Lighting Circuit to a separate service supply, but more

MODEL OF SWITCHBOARD & DIMMER SCHEDULE

MASTER	GRAND MASTER	LIGHTS CONTROLLED	LAMPS QUANT	LAMPS WATTS	LAMPS TYPE	DIMMER WATTS	MAGAZ. CIRC'S	SWITCHES MAIN	SWITCHES MASTER	SWITCHES INDIVID.
WHITE STAGE	CROSS INTERLOCKING WHEEL DRIVE	FOOTLIGHTS	72	75	C	5400	3	3 POLE 1000 AMP. FUSED SWITCH STAGE MAIN	WHITE STAGE	2-POLE
		BORDER #1	60	75	C	4500	3			"
		" #2	60	75	C	4500	3			"
		" #3	60	75	C	4500	3			"
		TWO PROCENIUM STRIPS	12	150	C	1800	2			"
		INC POCKETS A & B	2	1000	C	2-1000	2			"
		" " C & D	2	1000	C	2-1000	2			"
RED STAGE		FOOTLIGHTS	72	60	B	4320	3		RED STAGE	"
		BORDER #1	60	60	B	3600	3			"
		" #2	60	60	B	3600	3			"
		" #3	60	60	B	3600	3			"
		TWO PROCENIUM STRIPS	12	150	C	1800	2			"
		INC POCKETS A & B	2	1000	C	2-1000	2			"
		C & D	2	1000	C	2-1000	2			"
BLUE STAGE		FOOTLIGHTS	72	60	B	4320	3		BLUE STAGE	"
		BORDER #1	60	60	B	3600	3			"
		#2	60	60	B	3600	3			"
		#3	60	60	B	3600	3			"
		TWO PROCENIUM STRIPS	12	150	C	1800	2			"
		INC POCKETS A & B	2	1000	C	2-1000	2			"
		C & D	2	1000	C	2-1000	2			"
		TWO ARC POCKETS	2	50A	ABC	NONE	2			"
		MUSICIANS OUTLET	30	40	B	"	3			"
WHITE HOUSE		MAIN DOME	1	1800	FIXT	1800	2	3 POLE 600 A. FUSED SW. HOUSE MAIN	WHITE HOUSE	"
		BALCONY & BOX	118	40	B	4720	5			"
RED HOUSE		MAIN DOME	1	1800	FIXT	1800	2		RED HOUSE	"
		BALCONY & BOX	118	40	B	4720	5			"
		AUDT BRACKETS	50	25	B	1250	4			"
BLUE HOUSE		MAIN DOME	1	1800	FIXT	1800	2		BLUE HOUSE	"
		BALCONY & BOX	118	40	B	4720	5			"
		SPARE				NONE	4			"

FIG. 110

usually by connecting behind the main house meter and fuses.

These methods fail because the same short circuit that might start a fire would simultaneously blow the service fuses, the transformer and manhole fuses as well. An accident at the power house, a storm affecting overhead supply lines, a burnout or ground in the transformer may put the service entirely out of commission and plunge the theatre in utter darkness. The darkness alone might cause a panic and would surely do so if accompanied by any other unusual occurrence.

The terrible results of a panic in the dark, no matter what the cause, can be avoided by installing a *Usem Emergency Lighting System.*

A Usem Emergency Lighting System comprises a storage battery amply large to carry all the emergency lights for a period of one hour, a rack or cabinet for the battery, a Potentiostat panel equipped with special magnetic switches, trouble detectors and signals, volt and ammeter, etc., and where the service is alternating current, a transformer for operating the emergency circuit during normal times.

When the current is alternating, if the theater be already wired with a separate emergency circuit, it is merely necessary to install the Potentiostat and batteries and connect this circuit thereto. The lamps should be changed to 15 watt, 30 volt high efficiency bulbs.

For normal operation, current is supplied through a 30 volt transformer mounted on the panel, and, in the event of the failure of voltage, this circuit is automatically transferred to the storage battery, the lamps then being supplied

with direct current. When the alternating voltage is restored, the emergency lights are automatically transferred to the transformer circuit.

When the current is direct, it is necessary to install two emergency circuits, one operating on 110 volts, which is in regular use, and the other operating on 30 volts from the Potentiostat only when the first fails. If the 110 volt current is restored on circuit No. 1, circuit No. 2 is automatically disconnected.

Usem Emergency Lighting Potentiostats are regularly made in five sizes to supply circuits of 7 to 40, 15 watt, 30 volt, special lamps, which may be mounted inside or outside the exit lanterns or both inside and outside.

LIGHT

That light travels with a speed which is much greater than the speed of sound is shown by the fact that the flash of a distant gun is always seen long before the sound of the report is heard and that lightning always precedes thunder.

For most purposes it is sufficiently accurate to take the velocity of light as 186,000 miles per second.

Light always travels out from a source in straight lines.

Up till the year 1800, the Corpuscular theory of light was the one most generally accepted, that light consists of streams of very minute particles, or corpuscles projected with the enormous velocity of 186,000 miles per second from all luminous bodies. The facts of straight line propagation and reflection are exactly as we should expect them to be if this were the nature of light.

A usual hypothesis which was first completely formulated by the great Dutch physicist—Huygens (1629-1695), regarded light like sound, as a form of wave motion. This hypothesis met at the first with two very serious difficulties; in the first place light, unlike sound, not only travels with perfect readiness through the best vacuum which can be obtained with an air pump, but it travels without any apparent difficulty through the great interstellar spaces which are probably infinitely better vacua than can be obtained by artificial means. If, therefore, light is a wave motion, it must be a wave motion of some medium

which fills all space and yet which does not hinder the motion of the stars and planets. Huygens assumed such a medium to exist, and called it ether.

The second difficulty in the way of the wave theory of light was that it seemed to fail to account for the fact of straight line propagation. Sound waves, water waves and all other forms of waves with which we are familiar bend readily around corners, while light apparently does not. It was this difficulty chiefly which led many of the famous philosophers, including the great Sir Isaac Newton, to reject the wave theory and to support the projected particle theory.

Within the last hundred years, however, this difficulty has been completely removed and in addition other properties of light have been discovered, for which the wave theory offers the only satisfactory explanation. If the wave theory is to be accepted, we must conceive with Huygens, that all space is filed with a medium, called the ether, in which the waves can travel. This medium cannot be like any of the ordinary forms of matter; for if any of these forms existed in interplanetary space, the planets and the other heavenly bodies would certainly be retarded in their motion. As a matter of fact, in all the hundreds of years during which astronomers have been making accurate observation of the motion of heavenly bodies no such retardation has ever been observed. The medium which transmits light waves must therefore have a density which is infinitely smaller even in comparison with that of our lightest gases. The existence of such a medium is now universally assumed by physicists.

Just as sound waves are disturbances set up in the air by the vibrations of bodies of ordinary dimensions, so light waves are disturbances set up in the ether probably by the vibrations of the minute corpuscles or electrons, of which the atoms of ordinary matter are supposed to be built up. Since these corpuscles are extremely small in comparison with ordinary bodies it is not surprising that their rates of vibration are enormously larger than the vibration rates of tuning forks, or other bodies which send out sound waves. Just how these corpuscles are set into vibration and in just what manner they vibrate, we cannot say as yet with certainty, but since we do know that an increase in the temperature of all bodies means an increase in the agitation of the molecules and atoms of which these bodies are composed, it is not surprising that the vibrations which communicate light waves to the ether take place in general in bodies which have a high temperature and that the hotter the body becomes the more intense become the light waves which it emits.

PRINCIPLES OF OPTICAL PROJECTION

The process is almost the reverse of ordinary photography. For instance, in photography a scene by means of the photographic objective or lens is photographed and a reduced image is obtained on ground glass. This glass is replaced by a sensitized plate and by the use of chemicals the image is fixed thereon.

In projection the process is reversed, that is, a transparent slide is made from the picture, or the

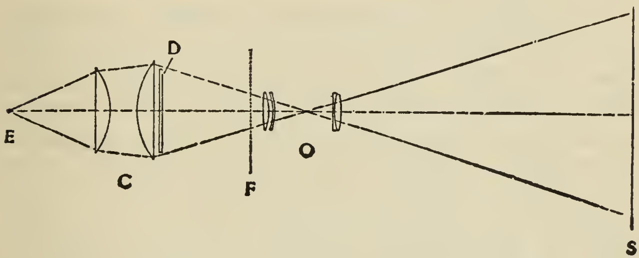


FIG. 111

roll of film taken with the motion picture camera is developed and used in the motion picture machine (the projector). By means of a condensed light they are strongly illuminated and with an objective lens an enlarged image is projected upon the screen, this screen image corresponding to the real objects photographed. The principles of optical projection for motion picture machines will readily be understood from the diagram Fig. 111.

At *E* is an electric arc or other suitable illuminant, the light from which is caught up by the condenser *C*. This condenser is an arrangement of lenses so constructed as to gather up the greatest volume of light possible and to concentrate the light which it gathers at the center or diaphragm plane of the objective when the objective is located at the proper distance from the film, which distance is determined by the focal length of objective lens.

The film should be placed at such a point that the entire area of the aperture in gate is fully illuminated, and it should also be placed so that the greatest number of light rays possible should pass through it.

Proceeding from the slide *D* or film *F* the light passes through the objective *O*, where the rays cross, and the object is therefore reversed, by means of the objective, the object is also imaged or delineated upon the screen *S;* the degree of sharpness or flatness of the image depends upon the optical connection of the lens.

Great care should be taken to line up properly the arc, condensers and the objective lens, as under the best of conditions less than 5% of the light from arc reaches the screen.

LENSES

The optical system of a moving picture circuit comprises:

(*a*) The arc lamp or mazda lamp.
(*b*) The condensers.
(*c*) The lens, or objective.

The optical system is a very important one and one that has long been neglected by the majority of operators. A number of men who have been operating machines for years have never taken the lenses apart and have no idea of the different combinations making up the objective lens.

There is no motion picture book published that we know of which goes far enough into this matter, and we would advise anyone desirous of getting all the information possible on lenses to study the books dealing with this subject that may be found in the various libraries.

The following is an outline of what an operator should know, and has been gathered from several books dealing with optical systems and lenses.

Reflection. The change of direction experienced by a ray of light when it strikes a surface and is thrown back or reflected. Light is reflected according to two laws:

(*a*) The angle of reflection is equal to the angle of incidence.

(*b*) The incident and the reflected rays are both in the same plane which is perpendicular to the reflecting surface.

Refraction. The change of direction which a ray of light undergoes upon entering obliquely a medium of different density from that through which it has been passing. In this case the following laws obtain:

(*a*) Light is refracted whenever it passes obliquely from one medium to another of different optical density.

(*b*) The index of refraction for a given substance is a constant quantity whatever be the angle of incidence.

FIG. 112
Condenser Combinations

(*c*) The refracted ray lies in the plane of the incident ray and the normal.

(*d*) Light rays are bent toward the normal when they enter a more refracted medium and from the normal when they enter a less refracted medium.

A lens may be defined as a piece of glass or other transparent substance with one or both sides curved. Both sides may be curved, or one curved and the other flat.

The object of the lens is to change the direction of rays of light and thus magnify objects or otherwise modify vision.

Lenses may be classed as:

Double convex	Double concave
Plano convex	Plano concave
Concavo convex	Convexo concave

The focus of a lens is the point where the refracted rays meet.

Spherical Aberration. The reflected rays of concave spherical mirrors do not meet at exactly the same point. This is called spherical aberration.

Effect of Spherical Aberration. It produces a lack of sharpness and definition of an image. If a ground glass screen be placed exactly in the focus of a lens the image of an object will be sharply defined in the center but indistinct at the edges, and if sharp at the edges it will be indistinct at the center. To avoid this a disc with a hole in the center is placed concentric with the principal axis of the lens, thus only the center part of the lens is used.

Chromatic Aberration. When white light is passed through a spherical lens, both refraction and dispersion (the decomposition of white light into several kinds of light) occur. This causes a separation of the white light into the various colors and causes images to have colored edges. This effect which is most observable in condenser lenses is due to the unequal refrangibility of the simple colors.

Achromatic Lenses. The color effect caused by the chromatic aberration of a simple lens greatly impairs its usefulness. This may be overcome by combining into one lens, a convex lens of crown glass and a concave lens of flint glass.

Back Focal Length. The distance from the back of the lens to the film in the gate of machine while the film is in focus on the screen. (Written B. F.)

Equivalent Focus. The distance from a point half way between the back and front combination of lenses to the film in the gate while picture is in focus on screen.

Can be obtained by measuring distance between the front and back combination then dividing by two and adding the result to the back focal length. (Written E. F.)

Objective Lens. The objective lens of a moving picture machine generally consists of four lenses, two in the front combination and two in the rear. The two lenses in the front are cemented together with Canada Balsam and called the compound lens. The back combination consists of two lenses separated by a metal ring, called the duplex lens.

The convex or greatest convex side of a lens always faces the screen.

It is absolutely necessary to keep the lenses clean; it will be impossible to get good definition or sharp focus on the screen if the objective lens is not scrupulously clean. Never place the fingers on the glass surface of lens, as though it may not show when looking through the lens it will undoubtedly affect the definition of picture on screen.

Condenser lenses should be cleaned every day, and the objective lens once or twice a week. It will not be found necessary to take the lens apart to do this, as it will only be the exposed glass surfaces that will need attention. Use a clean

soft handkerchief for this purpose. The lens can be taken apart every three or four months and all surfaces thoroughly cleaned, great care should be taken when taking the lens apart so that you get the lenses back in the same position and order.

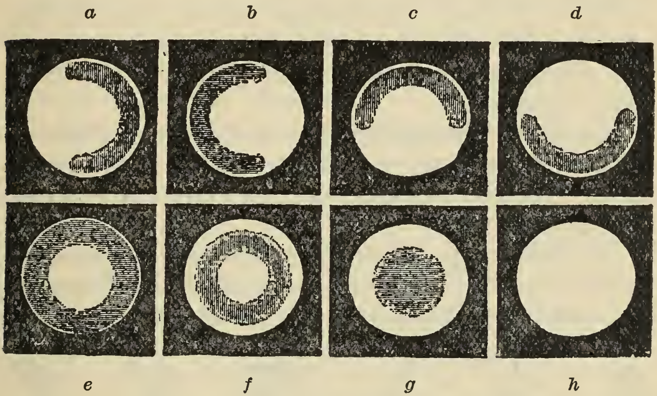


FIG. 113

a and *b* the crater of arc needs adjusting laterally to right or left
Figures *c* and *d* the crater too high or too low
Figures *e*, *f* and *g* the crater is too near or too far away from condenser
Figure *h* shows arc in correct position

Successful results in projection depend largely upon the correct adjustment of the lamp, which must throw a brilliantly illuminated clear circle on the screen. After the objective is focused as will be evidenced by a sharp, clear image on the screen, examine the illuminated circle. If the light be centered and the lamp correctly adjusted, the circle will be entirely free from coloration or shadows. In Figures *a* and *b* the crater of arc needs to be properly adjusted laterally, it being

as shown too far to the right or left. Figures *c* and *d* show the crater too high or too low. In Figures *e*, *f* and *g* the crater is too near or too far away from condensers. Figure *h* shows it in right position, the screen being free from all shadows or ghosts.

Fig. 114 shows the various lenses: (*a*) double convex; (*b*) plano convex; (*c*) concavo convex; (*d*) double concave (*e*) plano concave; (*f*) convexo concave.

The first three are thicker at the center than at the border, and are called converging; the second three which are thinner at the center are called diverging.

The following articles on condensers were prepared for and printed in the S. M. P. E. Transactions and reprinted here by permission.

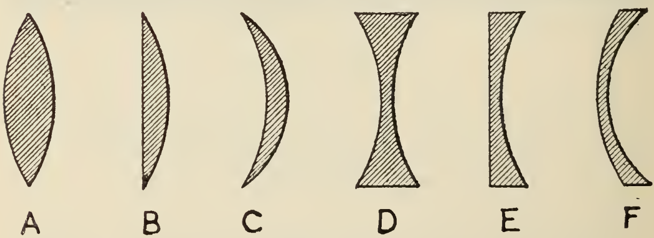


Fig. 114

CONDENSERS, THEIR CONTOUR, SIZE, LOCATION AND SUPPORT

Surprisingly little literature has been written on the subject of condensing lenses, and none at all with regard to their use in motion picture projecting machines. Investigators outside our own art have so far failed to observe that the problem is not the same in a motion picture projecting machine that it is in a stereopticon lantern, a difference resulting from the necessity for the use of a shutter with the motion picture projector.

Condensing lenses are employed because it is practically impossible to illuminate the film directly. When we get a cold light it may perhaps be feasible, though this is debatable. But for the present, condenser lenses, for gathering the diverging rays of the luminant and converging them on the picture aperture, continue to be used.

Two lenses are usually employed in combination for the reason that to get the same gathering power with the same convergence in a single lens there would be too great a loss of light by reflection from the curved surfaces. So lantern makers usually take two plano-convex lenses and mount them with the curved surfaces together, which puts a flat side next the light source.

As a simple but rather interesting experiment showing the loss of light by reflection, hold up your next glass of water and try to look upward

through the surface of the water at about 45° angle. You will not be able to see anything above the water until it actually touches the surface.

This total reflection phenomenon is usefully employed in many ways, e. g., in engraving plants to reverse the picture for etching; in binoculars to give a large field and long-range-telescope in short, compact form; in periscopes to see without being seen; in the Graphoscope for mechanical simplicity and convenient operation.

But this same reflection when from the surface of a single condenser, is a very decided loss. For this reason it is usual to employ two lenses in a condenser system. The first lens, the lens next the source of light, an electric arc usually, is popularly described as gathering the diverging rays and paralleling them, the second lens then converging them on the aperture plate. Lenses of 6½ and 7½-inch focus are usually employed for short projection distances, with the arc lamp 2½ to 3 inches from the surface of the arc lens.

To parallel the light rays with these two lenses the arc should theoretically be 6½ inches from the lens. But this is not best, for at the closer position more than four times as much light at the aperture results. If the rays could be paralleled by the first lens, the arc lens, then the converging lens might be any distance away. Because the arc lens cannot do this, the second lens, the converging lens, is brought up close to the arc lens in order to catch as large a portion of the rays as possible and concentrate them on the picture aperture.

Authorities on lenses have heretofore recommended that these converging light rays cross in the center of the projecting lens, but their conclusions have been based upon the old lantern slide assembly which had the pictures just in front of the converging lens, and did not employ a shutter at all. Their recommendations are not, therefore, wholly applicable, nor is the arrangement proposed for the lantern the best for motion picture projecting machines.

It might be nearer right if we could get lenses made so that the shutter could cut across the rays at the narrowest part, that is, at the diaphragm location in the lens. But this is not practical, because, among other things, a variety of focal lengths of projecting lenses is required for different projection distances, or "throw" as the operator usually terms it. The preferable arrangement is, therefore, to put the shutter in front of the lens, and then to have the rays of light cross at that point.

The principal reason for having the shutter at the narrowest part of the projected light-beam is that the obscuring blade may be as narrow as possible, so that when the other two blades, the flicker blades, are added they may each approximate the width of the obscuring blade and yet give a fifty-fifty ratio of light to darkness, which is the ideal arrangement for a flickerless picture today.

To readily determine where the light beam is narrowest is not always easy, for the light cone is not readily discernible. If, however, a card is passed vertically through the light just in front of the lens, a shadow will cross the screen, say, from top to bottom; with the card farther out

the shadow will cross from bottom to top; but at a median position the passing of the card causes a shadow to cover the whole screen at once. That is the proper location for the shutter. One should remember, however, that a shutter that is just right, that is, most efficient, at this point will show halation or streamers, both above and below the letters of a title, if the arc is moved very much either toward or away from the condensers.

There are other factors also which have a bearing on the location of the various elements of the projection system. For example, a longer projection for the same size picture requires a projection lens of longer back focus. This again requires a longer cone of light from the converging lens. This lens must, therefore, be changed for one having less curvature. But when this is done the light spot on the aperture is too large, and the lamp house must be moved back. This draws the apex of the light cone back within the projecting lens barrel, so that another change is required. By repeated trials one would probably find the proper lens and best lamp-house position, but the easier plan is to advance the arc a little when an approximately correct lens and lamp-house position is found, and this is usually done.

When the lamp-house is moved back for the long "throw" it is not unusual to change the arc lens to a 7½ lens, making the combination two 7½ lenses. The resultant light loss is considerable, however, 50 per cent, perhaps. This loss of light has given rise to an erroneous idea that the longer throw requires a correspondingly greater amount of current for a given size screen. Another plan is to let the 6½ arc lens alone, and substitute an

8½ lens for the 7½ converging lens. This will give the same amount of light on the same screen at the longer distance, without increasing the current consumption. A 6½-inch and 8½-inch lens combination has practically the same equivalent focus as two 7½-inch lenses, though the reciprocals are not exactly identical in both cases. However, the distortion of poor lenses sometimes prevents getting an even, white-lighted screen.

This brings us very naturally to the consideration of a better lens arrangement for the lens next the arc, for, if this can be made a fixed factor, then the matter of adjustment for different lengths of throw is simplified.

Taking up the consideration of the arc and the theoretically best adjacent lens-surface it is at once apparent that if a curved surface could be employed, the same safe distance might be maintained between the arc and the lens at its center, while the outer edge of the lens, by reason of its enveloping curvature, would gather very much more light. But to make a single lens of this conformation having the same 6½-inch focal length as the plano-convex usually employed gives the opposite or convex surface of the lens a disastrous curvature. A better plan is, not to attempt the total light refraction with the one lens, but set another close thereto having such a curvature that the sum of the two will give the focus desired. A lens of — 1½ and + 6½ (dioptric measurement), say 8-inch focus, in combination with a 10-inch, either bi-convex or a plano-convex, is about correct for a three-inch arc location and is an ideal arrangement, but unfortunately, it is only ideal. A meniscus of six-inch focus would have to

be about + 7 which, obviously, is not practical. The use of a — 1½ and + 5½ lens, about 10-inch focus, in combination with either a bi-convex or plano-convex lens of 10-inch focus, is good, being approximately the equivalent of a 5-inch lens. This combination used with a 7½, 8 or 8½-inch plano-convex, seems to make a very satisfactory three-lens meniscus set.

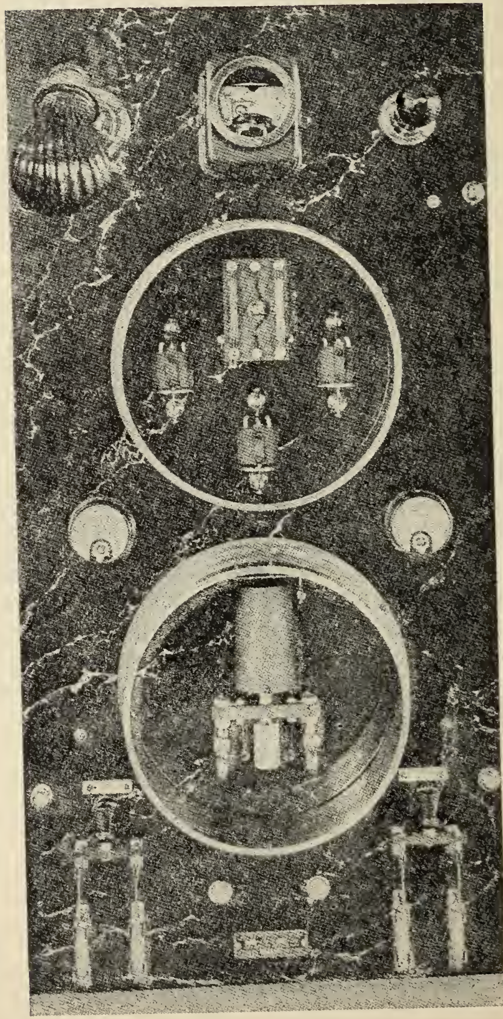
There is still another factor to be taken into consideration—namely, the liability of condenser breakage. But, as has been explained, if the arc can be kept close to the lens very much less current is required for the same screen illumination. And right here a Kelvin law helps us very materially, i. e., "the light of an arc lamp increases directly as the increase in current, while the heat increases as the square." Obviously, therefore, if we can employ such an arrangement as will require but half as much current as another we get but one-fourth as much heat.

But at best the heat is such that the condenser gets very hot though the heat of itself alone does not crack lenses. In actual practice I have found that if the arc lens is held in a non-conductive ring it will never break no matter how hot it gets. Lenses crack because of unequal stress in the glass, and this comes about because something has carried away heat from a limited area and not from the whole mass evenly. Thus, if one should touch a very hot lens with a piece of metal, say, a screw driver, the lens will crack, because the metal, being a better conductor of heat than the glass, robs the glass of its heat at the point of contact and the equilibrium of stress is disturbed and the glass cracks. I have had the glass crack

across between my thumb and finger when I attempted to pick up a hot lens by its edge (without knowing before that it was hot). If the lens is heated evenly and remains so, that is, is not robbed of any part of its heat by a conducting or convecting medium it will never break. A complete understanding of this phenomenon and its proper recognition by the operator would enable him to get a much more brilliant screen picture with much less current consumption.

It is exactly the same with many other improvements which might be attempted if we had graduate engineer operators to handle our machines. So the best we can do is to make a compromise machine and wait until the public grows up to our ideals.

Much of what is here explained could be calculated with exactness and applied by rule if the source of light were an infinitely small point, and condensers were as carefully ground and annealed as projection lenses, which, however, isn't the case. Also the condensers and light source area have a definite bearing on the sharpness and brilliance of the screen picture aside from the question of illumination.



PRE SET SWITCHBOARD

CONDENSER LENSES FOR THEATRE MOTION PICTURE EQUIPMENT

With the development of the Mazda lamp for motion picture projection the limitation formerly imposed in source-condenser spacing, due to heating and fouling, was obviated. Attempts were at once made to design condenser lenses of shorter focal length and capable of intercepting a larger percentage of the light from the source. A successful solution was the prismatic condenser, a special form of Fresnel lens, which includes a relatively large angle without excessive aberration.

With a lens of this design, however, there results a considerable loss of light deflected by the risers of the prisms. The light issues from the lens not as a solid cone, as from the plano-convex condenser, but in several concentric cones, one from each of the prisms and from the center double-convex section. This property is both an advantage and a disadvantage. A slide placed close to the condenser would obviously not be satisfactorily illuminated and thus in those small theaters in which separate stereopticon equipments are not installed, a planoconvex condenser must be added for slide projection, and provision made for moving the lamp. The great advantage involves the characteristics of the light source. The filament coils of the incandescent lamp do not present source area of uniform brightness. With the plano-convex condenser some unevenness in the beam remains at the aperture, but with the

several rings of the prismatic condenser the source is focused at different distances along the axis and the images are so superimposed that the beam is made practically uniform where it passes through the aperture. A further loss of light results thereby, inasmuch as a relatively greater amount falls outside of the aperture limits.

The actual relative net results in screen illumination with the two types of condenser lenses have, so far as we are aware, never heretofore been completely ascertained and stated. General conclusions have been drawn from observation with a limited range of sizes, focal lengths, and spacings of the optical elements. Experiences by other individuals under somewhat different conditions did not seem to check these general conclusions and there has been a distinct feeling of uncertainty in the minds of many as to the exact facts. In order to contribute to a clarification of this situation, a comprehensive investigation was undertaken of total light flux projected to the screen, its distribution, amount of aberration, and required precision of adjustment with the commercial plano-convex and prismatic condenser lenses.

For the purpose of this investigation the light source form and dimensions, mirrored reflector, condenser diameter, and aperture were considered as constant from a commercial standpoint. The light flux projected and evenness of screen illumination are then dependent on the following variables:

Condenser focal length,
Source-condenser distance,
Condenser-aperture distance,

Mirrored reflector adjustment,

Projection objective diameter,

Projection objective working distance (back focus).

In these tests the condensers and objectives included below were employed:

Plano-convex spherical condensers, 4½-inch diameter—

6½ and 6½-inch foci,

6½ and 7½-inch foci,

7½ and 7½-inch foci.

Prismatic condensers, 4 7/16-inch diameter—

2½ and 6½-inch rated working distances.

Projection objective lenses—

No. 1 (quarter size) of 3⅝, 4, 5½ and 7½ inches equivalent foci.

No. 2 (half size) of 5½ and 7½ inches equivalent foci.

Spherical mirrored reflector, 5¼-inch diameter, 3⅜ inches outside radius of curvature.

Standard aperture, 0.680 by 0.906 inches.

MAZDA C lamps, 30-ampere, 28-32 volt, T-20 bulb.

Monoplane filament, 0.43 inches wide and 0.5 inches high.

A number of condensers and objectives were measured for light transmission and the several units used were selected as representative of the good commercial product. The plano-convex condensers showed transmissions of from 88.3 to 89.9 per cent for each lens of the combination; they were imported ground lenses and were free from any marked yellowish tint. The prismatic condensers showed a similar uniformity. The trans-

missions of the objectives were about 71.5 and 68 per cent for the No. 1 and No. 2 sizes respectively.

The lamps were checked at intervals throughout the tests to insure constant candlepower.

Total light flux and screen illumination data were obtained with a Weber photometer, whose calibration was checked periodically.

TEST PROCEDURE

Plano-Convex Condensers

Using the plano-convex condensers, the aperture - condenser and condenser - source spacings were varied independently for each objective and the appearance of the screen was recorded, using the nomenclature given in Table 1. The degree of unevenness of illumination considered as permissible and denoted by the letter A was just less than that which would be detected during the projection of light density films, such as animated cartoons. The designation AA was applied to the most even illumination as revealed on close inspection without film.

TABLE 1

NOMENCLATURE FOR SCREEN APPEARANCE

AA	Good even screen.
A	Slightly uneven screen but satisfactory for projection purposes.
B	Rings barely noticeable.
C	Bad rings or spots noticeable with a clear film.
D	Vertical or horizontal streaks barely noticeable.

E Bad streaks noticeable with clear film.
F Noticeable color, edge or corners.
G Bad color.

Parentheses denote results with mirrored reflector.

Asterisks denote screen appearance not suitable for motion pictures.

With several fixed aperture-condenser distances within the practicable range the source was moved back from the condenser until a maximum permissible unevenness of screen was obtained. With increased distance between source and condenser, the screen illumination become more uneven; the maximum spacing for permissible unevenness was noted as indicated in Table 2. The total light flux directed to the screen was measured for each of these limiting settings and for such further points as was necessary to determine whether the settings corresponded to maximum screen illumination. Measurements of the illumination at sixteen points over the screen area were then made for these same settings so that the visual impression might be checked against quantitative data. The above procedure was followed through both for

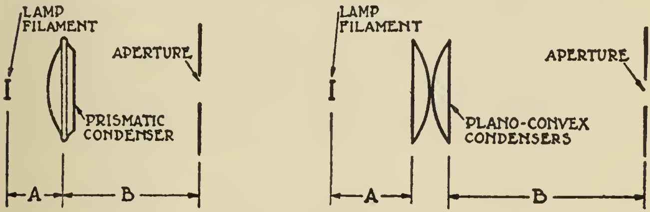


FIG. 115

Table 2

TYPICAL VISUAL TEST DATA FOR SCREEN APPEARANCE

No. 2, 7½″ E. F. Projection Objective
4½-inch diameter, 6½″-6½″ plano-convex
condenser combination

Aperture-Condenser Distance, Inches	Source-Condenser Distance, Inches	Appearance of Screen
7	2	AA(AA)
7	3	A*(AA)
7	3½	E*(AA)
7	3¾	E*(A*)
8	2	AA(AA)
8	3	E*(AA)
8	3½	E*(A)
8	3¾	E*(A*)
9	2	AA(AA)
9	3	E*(AA)
9	3¼	E*(A)
9	3½	E*(A*)
10	2	A(AA)
10	3	E*(A)
10	3¼	F*(A)
10	3½	G*(A*)
11	2	A*(AA)
11	2¾	E*(A)
11	3	E*(A)
11	3¼	G*(A*)

Parentheses denote results with reflector.
Asterisks denote screen evenness unsatisfactory for theater projection.

lamp alone and lamp with reflector. The mirrored reflector was in general set by observing the reflected image of the source projected by the condenser and objective on a card placed in front of the objective lens; in some cases it was necessary to place the card behind the objective in order to intercept a well-defined image.

Table 3 indicates the large loss in screen lumens when the source-condenser distance is decreased below that value at which usable evenness is obtained, due to the size of the beam at the aperture increasing at such a rate that a smaller percentage of the larger amount of light intercepted by the condenser passes through the aperture.

This procedure was followed through for the several equivalent foci objectives of both No. 1 and No. 2 sizes.

TABLE 3

REPRESENTATIVE VARIATION IN SCREEN LUMENS WITH CHANGE IN SOURCE-CONDENSER DISTANCES FOR CONSTANT CONDENSER-APERTURE DISTANCE

Aperture-Condenser Distance, Inches	Source-Condenser Distance, Inches	Lumens
6	5	372
6	4	182
7	4½	432
7	4	316

Table 4

VARIATION OF LIGHT FLUX AND SCREEN APPEARANCE WITH CHANGE IN OPERATING DISTANCE FOR PRISMATIC CONDENSER

5½-inch E. F. No. 2 Objective Lens—30-ampere 28-32 volt Lamp Without Reflector

Aperture-Condenser Spacing Inches	Condenser-Source Spacing Inches	Lumens on Screen Bare Lamp	Appearance of Screen	
			Bare	Mirror
6½	2¼	363	AA	(AA)
6½	2⅜	432	A	(AA)
6½	2½	48a	E*	(AA)
6½	2⅝	48a	E*	(A)
6½	2¾	4aa	E*	(E*)
6½	2⅞	4aa	E*	(E*)
4	2½	41a	AA	(AA)
5	2½	463	A	(AA)
5½	2½	463	D	(AA)
6	2½	467	D	(AA)
6½	2½	469	E*	(AA)
6¾	2½	468	E*	(AA)
7	2½	465	E*	(A)
7½	2½	454	E*	(A)
5	2⅝	477	E*	(AA)
5	2¾	498	E*	(A)
5½	2⅝	445	E*	(AA)
5½	2¾	498	E*	(A)
6	2⅝	492	E*	(A)
6	2¾	490	E*	(E*)
7	2⅝	465	E*	(A)
7	2¾	448	E*	(E)
7½	2⅝	442	E*	(E)
7½	2¾	418	E*	(E*)

*Screen evenness not satisfactory for theater projection.

Prismatic Condensers

The tests conducted with the prismatic condenser covered similar observations for the specific source-condenser and condenser-aperture distances and sufficient others to obtain total flux and evenness of illumination data on the effect of changing either distance independently, or both. Table 4 and the curves of Fig. 116 show the range of operating distances employed. In Table 4 the screen lumen values are given for the lamp without reflector, since the average increase due to the mirror bears a practically constant relation to the bare lamp values.

Plano-Convex Condenser With Slide Holder

The loss of light through the motion picture optical system, due to use of a slide holder, was obtained by measurement of the screen lumens for slide holder positions adjacent to and one inch in front of the plano-convex condenser lens, which are the usual limiting conditions for the projection of large slides with 4½-inch diameter condensers, and for the same optical system without slide holder.

Objective Lenses

The objective lenses were tested not only for light transmission, but the definition, aberrations, and image distortions were observed by the projection of special line gratings placed at the aperture.

SUMMARY OF RESULTS

A summary of the test data is given in Table 5. Inspection of these data shows that in making a selection of the best operating distances for the plano-convex condensers, for many objectives there is a choice both as to condenser focal length and working distance. In such cases, operating distances common to more than one objective were selected, making it possible to reduce the recommended number of working distances and condenser combinations to the four given below. For the No. 2 objectives a condenser and working distance combination is included which is not suitable for slides, but which gives considerably more light for motion picture projection.

While these working distances are not the same as those which have been standard practice, they give greater screen lumens; the difference is small, however.

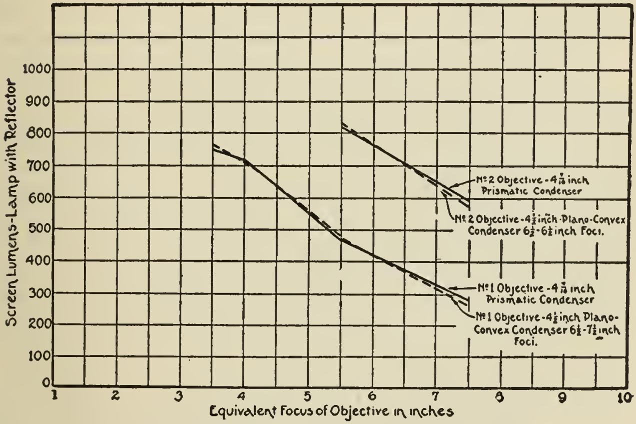
The graphs of Fig. 116 show that there is no appreciable difference in the light obtainable on the screen with prismatic and plano-convex condenser lenses of 4½ inches diameter, with correctly set reflectors.

They emphasize the enormous waste in light accompanying the use of No. 1 objectives in focal lengths above 5½ inches. Tests with the better grade of No. 2 objectives commercially available today show excellent definition and freedom from aberration, fully equal to the results obtained with the No. 1 lenses ordinarily employed in the past. Since double the amount of light will be projected to the screen when No. 2 lenses are employed, only objectives of this size and of the best quality

Objective Lens, Size	Equivalent Focus, Inches	Plano-Convex Condenser Combination	Spacings	
			Condenser-Aperture	Source-Clearance
No. 1	3½ to 5½	6½–7½	8	4
No. 1	5½ to 7½	6½–7½	9	3¾
No. 2	5½ to 7½	6½–7½	9	3¾
No. 2 (Motion pictures only)	5½ to 7½	6½–6½	8	3½

should be used in every installation requiring focal lengths above 5½ inches.

The data of Table 4 and the curves of Fig. 117 show the wide variation in condenser-aperture



Light Flux Projected to Screen with Prismatic and Plano-Convex Condensers of 4½-inch Diameter

FIG. 116

distance permissible with the prismatic condenser when the specified source-condenser distance of 2½ inches is used; a range of from five to seven inches is possible with no marked change in evenness of illumination or total flux projected. No other source-condenser and condenser-aperture working distance combination gave appreciably more light than the specified distances (2½ and 6½ inches).

For the plano-convex condensers the limits are narrower, and particular care is necessary to insure that the specified working distances are used.

In the laboratory careful adjustment of the mirrored reflector is necessary for the plano-convex condensers, if maximum screen illumination and uniformity are to be obtained. In practice this is very difficult to obtain; observation of the screen during a performance, and of filament

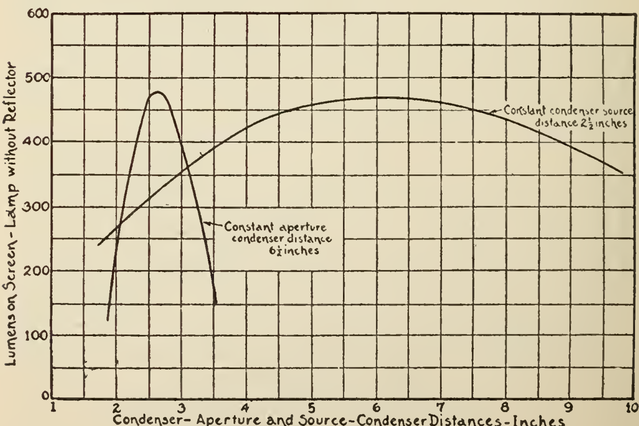


FIG. 117

TABLE 5

SUMMARY OF SCREEN LUMENS AND EVENNESS OF ILLUMINATION DATA FOR PLANO-CONVEX AND PRISMATIC CONDENSERS OF 4½-INCH DIAMETER

Condenser Lens	Source Condenser Spacing	Aperture denser Spac. ing	Lumens on Screen		% Deviation from Avg. Foot Candles (With Mirror)		% of Avg. Ft. Candles		Appearance of Screen†
			Bare Lamp	With Mirror	Max.	Min.	Avg. of Values Above Avg	Avg. of Values Below Avg.	
				No. 2. 5½″ E F. OBJECTIVE					
6½-7½ Pl. Cvx	3¾x	9x	433	760			118.8	86.1	E*(A)
6½-7½ "	3⅝	11	432	751			119.5	83.9	E*(A)
6½-7½ "	3½	11	399	712			116.1	85.6	E*(A)
6½-6½ "	3½xx	8xx	474	835			116.5	82.7	G*(A)
6½-6½ "	3½	9	459	797			123.5	78.7	G*(A)
Prismatic	2½	6½	481	828			104.5	94 3	A(AA).
				No. 2. 7½″ E. F. OBJECTIVE					
6½-7½ Pl. Cvx.	3½	10	311	545			104.4	93.9	G*(A)
6½-7½ "	3½	11	322	582			107.5	88.6	G*(A)
6½-7½ "	3¾x	9x	316	555			.....	.....	G*(A)
6½-6½ "	3½xx	8xx	329	581			107.4	90.6	F*(A)
6½-6½ "	3¼	9	326	580			107.6	89.7	E*(A)
6½-6½ "	3¼	10	328	573			112.0	85.9	F*(A)
7½-7½ "	4¼	9	254	466			106.3	92.9	F*(A)
7½-7½ "	4¼	10	297	535			104.3	92.4	G*(A)
7½-7½ "	4	11	286	505			104.3	93.5	G*(A)
Prismatic	2½	6½	339	598			105.3	93.5	E*(AA)
				No. 1. 3½″ E. F. OBJECTIVE					
6½-7½ Pl. Cvx.	4x	8x	431	766					G*(A)
6½-7½ "	3¾	9	392	710					F*(A)
6½-7½ "	3¾	10	402	718					G*(A)
Prismatic	2½	6½	431	750					A(AA)

No. 1. 4″ E. F. OBJECTIVE

6½-7½ Pl. Cvx.	4x	8x	404	711					G*(A)
6½-7½ “	3¾	9	384	670					F*(A)
Prismatic	2½	6½	403	714					A(AA)

No. 1. 5½″ E. F. OBJECTIVE

6½-7½ Pl. Cvx.	4	8	264	466	10.8	9.0			G*(AA)
6½-7½ “	3¾x	9x	268	480	7.5	6.6			G*(AA)
6½-7½ “	3¾	10	266	486	7.7	16.5			G*(AA)
6½-6½ “	3½	7	259	464	8.2	7.5			G*(A)
6½-6½ “	3½	8	262	479	8.4	13.1			G*(A)
6½-6½ “	3¼	9	258	469	8.5	13.0			G*(AA)
7½-7½ “	4½	9	252	461	7.9	9.2			G*(AA)
7½-7½ “	4½	10	266	479	8.9	20.3			E*(A)
7½-7½ “	4¼	11	251	462	11.6	25.3			G*(A)
Prismatic	2½	6½	255	471	11.8	11.8			E*(AA)

No. 1. 7½″ E. F. OBJECTIVE

6½-7½ Pl. Cvx.	3¾x	9x	154	278	5.4	5.2			F*(AA)
6½-7½ “	3½	10	157	280	7.7	6.4			F*(A)
6½-6½ “	3¼	8	154	276	6.0	5.0			G*(A)
6½-6½ “	3	9	154	274	8.4	5.7			F*(AA)
7½-7½ “	4¼	9	149	266	6.2	4.9			G*(AA)
7½-7½ “	4¼	10	154	278	6.3	5.5			G*(A)
Prismatic	2½	6½	161	287	12.8	16.2			E*(AA)

xRecommended Spacings. xxFor motion pictures only.
†Parenthesis denotes appearance with mirrored reflector.
Asterisk denotes screen not suitable for motion pictures.

images on a cord with the lamp operating at from 30 to 50 per cent normal current is not practicable in theaters from both operating and equipment standpoints. The most practical method of obtaining *good* reflector adjustments with these condensers in theaters is by the observation of four images of the filament on a card held about five inches in front of the dowser, as projected through four pinholes in the dowser, placed on both sides of, and above and below, the optical

axis. The pinholes should be placed about 1½ inches from the optical axis. Experience with plano-convex condensers and Mazda lamps in service has demonstrated that these semi-laboratory methods of adjustment give inferior results in the hands of even experienced projectionists, and other simpler methods of adjustment are actually used which result in a sacrifice of screen illumination or uniformity, or both.

On the other hand, with the prismatic condenser the mirrored reflector can be easily and satisfactorily adjusted by the observation of the filament images on the fire shutter coming from a single pinhole in the center of the dowser. The projection of a maximum amount of light is assured, with a high evenness of screen illumination.

The effect of placing a slide holder premanently in front of plano-convex condensers on a motion picture projector, is shown by the following typical data for 6½ and 7½-inch lenses and a 5½-inch e. f. No. 2 objective.

	Distance Slide Holder to Lens	Slide Holder Aperture	Lumens on Screen—Per Cent
Slide Holder in Position.	$\frac{1}{32}$ Inch	$2\frac{3}{4}''$x$3\frac{9}{16}''$	70.5
Slide Holder Removed. .	....	....	100
Slide Holder in Position.	1 Inch	$2\frac{3}{4}''$x$3\frac{9}{16}''$	83
Slide Holder Removed. .	....	....	100

The slide holder is ordinarily placed within one inch of the condenser in order that the slide will

be evenly illuminated over its entire surface. The resulting loss in light of from 15 to 30 per cent should be avoided by provision for either sliding the holder to one side, or raising it above the path of the beam during the projection of motion pictures. This has not been the practice, with resulting loss in screen brightness.

THE FUNCTION OF THE CONDENSER IN THE PROJECTION APPARATUS

Light radiates from every point of a source in all directions. If we had a very intense, and at the same time cold, point-shaped source, projection would be possible without any additional optical apparatus. Supposing we have such a source *s* separated by the distance *d* from a stencil *t* and at a distance *D* from the projection screen, the size of the image on the screen would be $\frac{D}{d}$ times the actual size of the Stencil or, differently expressed, the magnification $M + M = \frac{D}{d}$. The magnification may be changed in two ways:

(a) By keeping the projection distance *D* constant and varying the distance between source and stencil.

(b) By keeping the distance *d* the same and varying the projection distance.

The illumination on the screen is more favorable with the shorter projection distance, because a greater amount of the radiation from the source is utilized. The illumination in the center of the field is inversely proportional to the square of the distance *D* of the screen from the source. For points outside of the center of the projection field the illumination is less than in the center. If *a* be the angle from the source to a point of the field distant the length *b* from the center, the illumination *i* at the point will be proportional to the

cosine and the square of the sine of that angle and inversely proportional to the square of the distance from the center of the field to the point.

$$i = \frac{\cos a - \sin^2 a}{b^2}$$

To utilize more of the radiation from the source, we apply a condensing system, which takes in as large as possible a solid angle of the radiation from the source, and forms an image of this source at which the rays forming this image meet under a smaller angle or, more generally speaking, under an angle which is more suitable to the particular conditions of the case than the large angle of radiation taken in by the condenser.

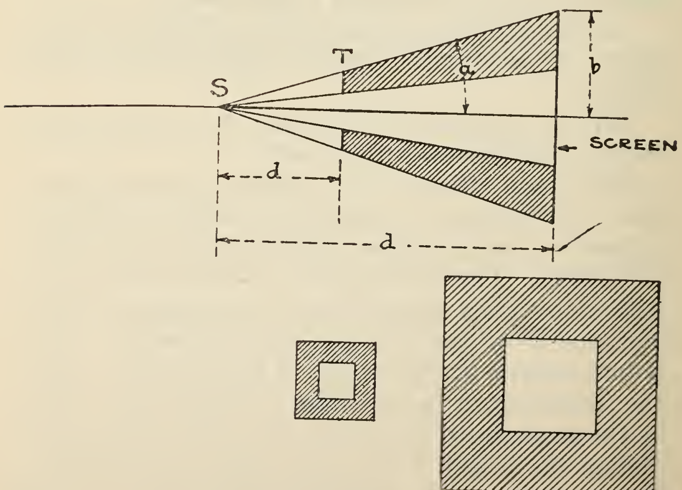


FIG. 118

By combining an optically perfect condenser, *i. e.*, a condenser which forms a point-shaped object, with a point-shaped source of great intensity, a very simple and perfect projection apparatus could be realized, which would need no projection lens and which would utilize a greater percentage of the energy radiating from the source than the condenserless arrangement. For example: In Figure 119, may be a point-shaped source and the distance between *s* and the condenser *c* may be shorter than the distance from the image of the source *s'* to *c*, so that the aperture of the condenser appears under a greater solid angle from the light source than from its image. If we assume the geometrical conditions on the image side of the condenser (location of stencil, angle under which the boundary rays meet at the image *s'*, projection distance, etc.) the same as the conditions in Figure 118, we will have a perfected image of the same size for the same projection distance, but with better illumination, because a greater solid angle of the radiation is intercepted by the condenser and made useful for the projection than is intercepted by the stencil in Figure 118.

The image *s'* can be considered in its effects like a real light source, with the difference that it radiates only within a limited solid angle, the apex of which is *s'* and whose base is the surface of the condenser.

The amount of radiation taken in by the condenser is proportionate to the square of the sine of the angle *u* between the optical axis and the ray through the margin of the condenser (which is half of the total angle taken in by the condenser).

If, for instance, the size of the stencil in figure 118 were 3″ x 2¾″, the diagonal would be with close enough approximation = 4″. Assuming a magnification of 10 at a projection distance of 113.4 inches, the resulting useful angle of radiation at the source would be 20°. If by using a condenser of suitable power, we intercept a larger angle of radiation while keeping the angle at the image the same, we will have an increase of illumination proportionate to the square of the sine of half the angle at the source. The amount of such possible increase may be seen from the following table:

Full angle $2u$ at source	Half angle u at source	sin u	sin $2u$
20°	10°	0.174	0.03
40°	20°	0.342	0.12
60°	30°	0.500	0.25
80°	40°	0.648	0.42
100°	50°	0.766	0.59
120°	60°	0.866	0.75

If we increase the angle u in our example from 10° to 20°, 30°, 40°, we shall have a relative illumination on the screen proportionate to 0.12, 0.25, 0.42 against 0.03, or taking the latter as unit, an increase of illumination of 4 times, 8.3 times, 14 times over the original case. This consideration does not take into account the loss by absorption and reflection in the passing through the condenser of the light.

Even though by use of the condenser we utilize a greater amount of radiation than without it, we must be aware of the fact that the greatest part of the radiation from the source is lost as indicated in figure 119, because the radiation within the solid angle intercepted by the condenser is

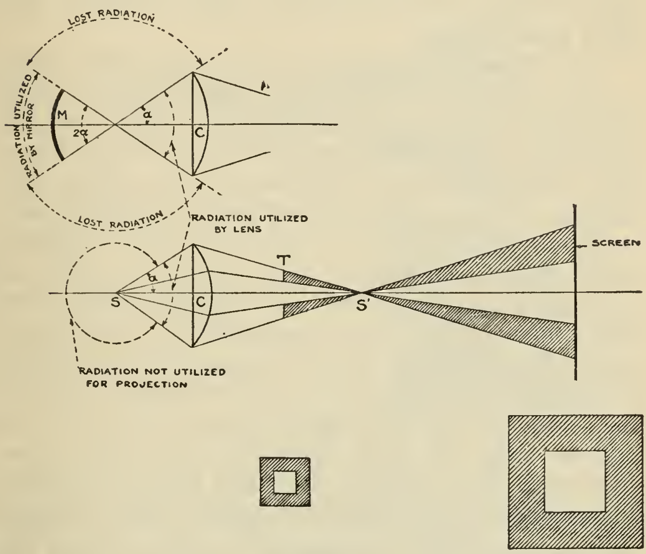


FIG. 119

only a small portion of the total amount, which the source sends out in all directions. For optical reasons it is impossible to increase the diameter of the condenser very much beyond a size which takes in an angle of about 90. The radiation within this angle can be increased considerably by placing a concave mirror behind the source so that

its center of curvature lies in the source, figure 119. Assuming no loss of light by reflection on the mirror and by passing through the source the quantity of light reaching the condenser should be doubled by this expedient.

The conditions so far assumed do not exist in practice, because neither the condenser is optically perfect nor the source point shaped. We shall consider an

(a) Imperfect condenser in combination with a point shaped source, and understand by term imperfect nothing due to careless making of the condenser, but those imperfections in performance which are due to the nature of a simple lens system. These are spherical and chromatic aberrations. On account of the former the different zones of the condenser will produce a series of images of the source; the nearer to the margin the zone, the nearer to the condenser the image produced by it, while with a spherically corrected condenser the rays from all the different zones of the condenser go through the same point, or the hollow cones of light formed by the circumference of the zone as base line have the same apices. These cones have different apices with a spherically uncorrected condenser, the apices lying the nearer the condenser lens, the greater the diameter of the zone. The rays which pass through the margin of the condenser will, therefore, intersect the axis at 2: figure 120, under a greater angle than the corresponding rays in the arrangement with the perfect condenser. This increase of the angles will be small for rays passing near the center of the condenser and will become the greater the nearer to the margin of the lens the

zone lies which produces the image. The effect is that the marginal parts of the field are imaged under a greater magnification than the center of the field. The image of a square object will show what is termed as cushion shaped distortion.

On account of the chromatic aberration, an uncorrected lens will produce images for the differ-

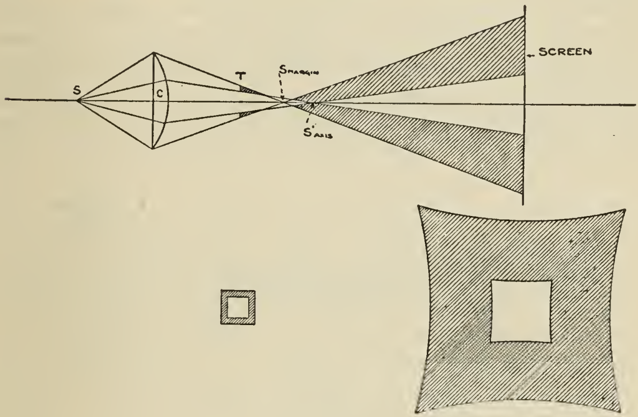


FIG. 120

ent colors composing the white light at the source at different distances from the condenser, the blue image being nearest to the lens, the green, yellow, red, etc., lying at greater distances in the sequence given. For each color, therefore, an image will be produced in the same way as shown in the previous paragraph having spherical aberration and lying at different distances from the lens. We have to imagine the blue rays forming a cone of the same general shape as just shown, the green ones another one, a little more pointed, because the green image lies farther away from the lens,

the red rays forming a still more pointed cone and so on. The precise shape of such a cone is further illustrated in figure 120. A point of a stencil interposed in this multitude of cones will be projected by the red, green, blue and so on rays at different places on the screen because these differently colored rays intersect the optical axis at different places and under different angles. Figure 121 shows how a white ray drawn to pass through the margin of the lens, the blue component, and of another white ray passing nearer to the axis, the red component goes through the

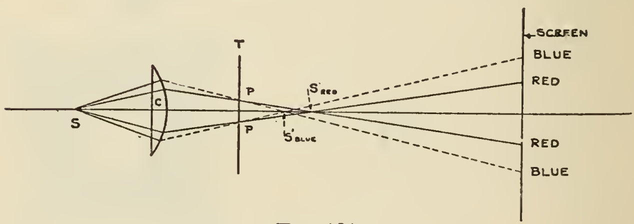


Fig. 121

transferred point P of the stencil. Figure 122 shows the projection of a transparent point of the stencil. The red ray projects the point at R (red) and blue ray at B (blue). The green and yellow images will lie between the red and blue ones, and in place of a white image we will have a series of colored ones forming a spectrum. The length of this spectrum is a minimum when the stencil is located near the condenser and increases as the stencil moves towards the image of the source. The amount of this chromatic aberration depends only upon the power of the lens, its aperture and

the magnification under which the source is imaged; in other words, if the location of the source and its image with reference to the lens and the angle a are given, the amount of chromatic aberration is determined. The thickness of the lenses has no influence upon it. Consider:

(b) The case of a perfect condenser and an extended light source. If the image of the light source is not point-shaped, the multitude of rays passing through a transparent point in the stencil causes a spot of light on the screen instead of a point, the size and shape of which is determined by the rays drawn from the object point through the different points of the image of the source. The figure 123 shows how the rays forming the image of the source and crossing at the object point pass from the light source through different parts of the lens. The size of the spot of light on the screen which represents the projection of an object point will depend upon the size of the source, or its image, as well as upon the location of the object point between the condenser lens and image of source. Projection in this simple manner is possible only if the detail of the object is coarse in comparison with the size of the image of the source. For projection of detail of a minuteness beyond a certain limit, a projection lens will have to be applied as will be shown later. Consider:

(c) The usual case of an imperfect condenser in combination with an extended light source. Instead of having one image of the source, each zone of the condenser will produce an image of the source at a different place of the optical axis and for each color contained in the radiation from

the source a different series of such images will be produced. The projection of the point takes place as described above under (a and b) with the result that the light patch on the screen, the so-called circle of confusion, will have colored fringes, red towards, and blue away from the center of the field. The spherical aberration will add distortion to the image in the way explained above.

The patch of confused light which appears on the screen in place of the image of the object point caused by the size of the light source and by the

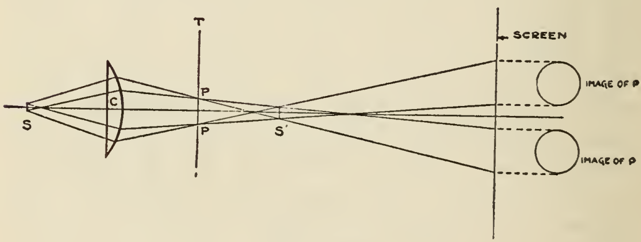


FIG. 122

chromatic aberration, can be converted into a true image of the object point by the interposition of a

(d) Projection Lens. Figure 123 shows the arrangement and also offers an explanation why in spite of the chromatic aberration of the condenser the image of the white object on the screen is white. We insert here that the image of the source must always fall in the aperture of the projection lens, which has to be large enough but need not be larger than necessary to pass all the radiation going from the condenser through the image of the source. The differently colored rays

which intersect in the object point belong to white rays which fall upon different zones of the condenser lens. For instance, of the white ray from the source (1) a red component is refracted in the direction of the object point, while of a white ray (2) a blue component and of another white ray lying between (1) and (2) the green component leaves the condenser in the direction of an object point. This multitude of colored rays passing through the object point must, therefore, comprise all of the colors composing the light of the source and when gathered by the projecting lens and all brought to the same image point on the screen, form a white image of the object point. It is very evident also, that the image on the screen is white only if *all* the colored rays which may possibly go through the object point are united in the image on the screen. If, for instance, the diameter of the condensers were too small to pass the ray (2), the image would appear reddish yellow instead of white, because the blue is missing, or if the diameter of the projection lens were to be too small to let the red ray pass the image of the point would be bluish.

As long as we take care not to rob the pencil forming the image on the screen of any of its colored components, we shall have no difficulty on account of the chromatic aberration of the condenser. Of much greater influence is the effect of the spherical aberration. To obtain an even illumination of the screen, the section through the cone at the location of the stencil must be evenly illuminated. The cone of a perfect condenser offers sections with even distribution of light any-

where between the condenser lens and the image of the source—figure 124. There is a slight falling off of the illumination towards the margin for the same reason as stated at the beginning of this paper. A condenser which has spherical aberration will produce a cone in which the distribution of light is even only in sections near the condenser lens. The sections approaching the image of the source show a more and more increasing accumulation of light near the margin of the section because here the rays are more crowded together than in the central part of the field as may be seen

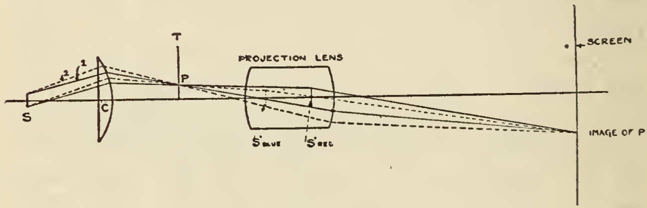


FIG. 123

in the figure. This is of no significance in lantern slide projection because the slide on account of its size is always located near the condenser, but very disturbing when, as in motion picture projection, the stencil is small and moved nearer to the image of the source. If we place the stencil so that its diagonal is equal to the diameter of the cone, we shall have its corners in the marginal concentration of the light and, therefore, an uneven illumination of the stencil (see figure 124). To avoid this, the stencil has to be moved towards the condenser until its whole area lies in the evenly illuminated part of the cone. This means, of

course, the loss of a very great percentage of light. The mere fact that a condenser has spherical aberration does not entail any loss of light if we are satisfied with an uneven illumination as long as the aperture of the projection lens is large enough to receive all the light passing through the image of the source. The sharpness of the image on the screen is not influenced by the spherical aberration of the condenser, if only the illu-

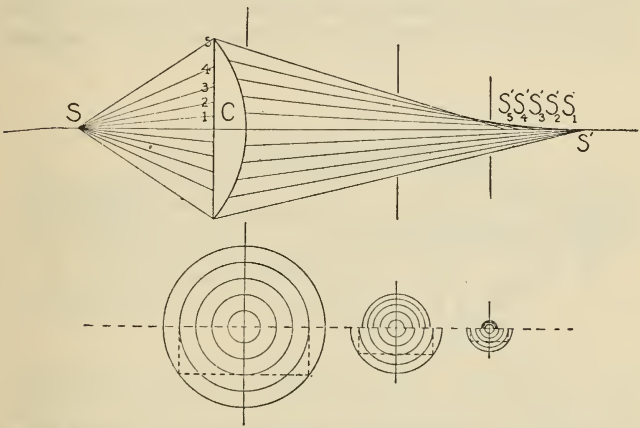


FIG. 124

minating system is so centered that the image of the source, the spot, lies symmetrically to the center of the projection lens. If a slight decentration of the spot, without the spot getting outside of the aperture of the projection lens causes a deterioration of the image on the screen, the fault lies in the projection lens.

Another factor of influence upon the efficiency of a given combination of light source, condenser

and projection lens is the size of the source and the location of the mat forming the border around the picture, the so-called aperture plate of the apparatus. The actual amount of light traveling from the condenser to the image of the source is embraced in a cone, the base of which is the condenser and the apex the image of the source. If the source is not point-shaped, the cone will be truncated.

We consider first a point-shaped source. If the stencil is of rectangular shape and its diagonal

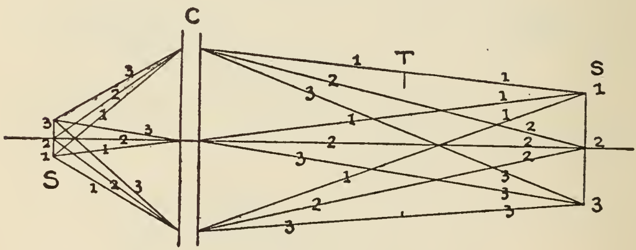


FIG. 125

equal to the diameter of the light cone at the position of the stencil, the four segments of the illuminated source outside of the stencil do not contribute to the illumination. We shall refer to this in the following as diaphragm action (I). This is perfectly self-evident and there is no remedy for this loss unless we make the stencil circular. See figures of the half rectangles inscribed in the sections through the lower cone. Rectangular condensers have been suggested and are resuggested now and then, but instead of saving light,

they cut out the unused light at a different plane of the optical system. They serve no purpose and are more expensive to make and to mount than the ordinary round condenser.

In case of a source of extended area the aperture plate does not only cut off these four segments, but also screens off parts of the condenser or of the light source in such a way that, while the radiation from the central parts of the source, which fills the condenser aperture, reaches the image of the source and, therefore, is utilized, the

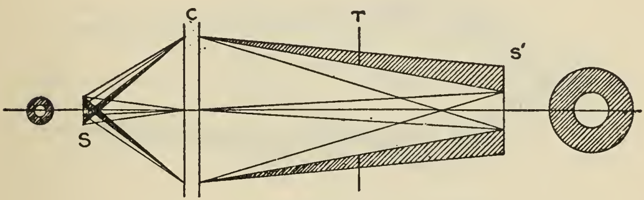


FIG. 126

radiation from the extra axial points of the source, although it passes through the condenser, only partly reaches the image of the source and contributes to the illumination of the object point. We shall call this in the following diaphragm action (II.)

To simplify the drawings the light source and the aperture plate in the following are assumed to be circular. Figure 125 shows the path of the light rays from the center and from the two ends of the source as they pass through the condenser towards the image of the source *s* and *s'* are two conjugate points of the source and its image and

the rays connecting them are designated with the same figures (1), (2), (3).

Figure 126 illustrates how the ray from point 1 through the lower margin of the condenser does not reach the image point 1 and how the angle of useful radiation is smaller by the shaded portion than it would be were it not for the diaphragm action of the aperture plate.

Only the portions in the middle part of the

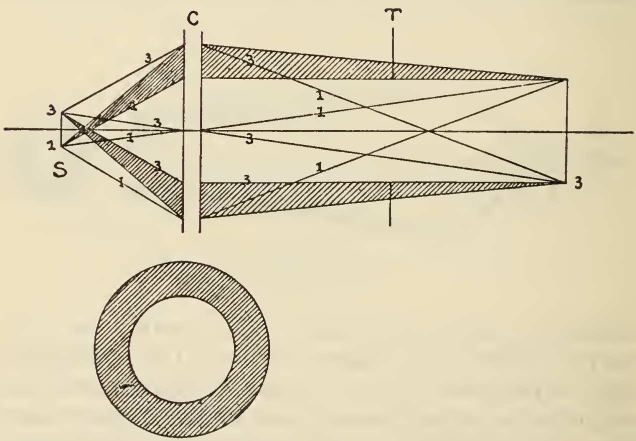


FIG. 127

source send forth cones which fill all the aperture of the condenser, while all the shaded parts of the pencils from points 1 and 3 are intercepted by the aperture plate as illustrated by the next drawing, figure 127.

We have to consider next the loses caused by Absorption and reflection. The amount of light

lost by absorption in a piece of glass depends upon the absorption coefficient of the material and on the thickness of the piece. The absorption coefficient varies from 1.3% per cm. for very clear glass to about 4% per cm. for very bad glass. The loss of light in a lens varies with the zones through which the light passes, depending on the different lengths of the path between the surfaces.

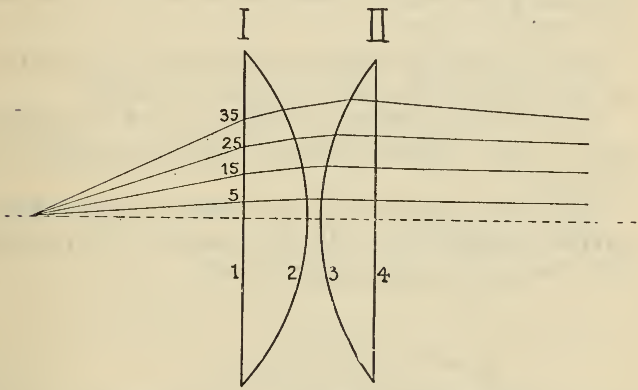


Fig. 128

The loss by reflection depends upon the index of refraction of the glass and upon the angle of incidence under which a ray strikes the surface. It increases, therefore, towards the margin of the condenser because the angles of incidence are greater there than nearer the center of the lens.

The following two tables show for 4 different zones of an ordinary M.P. condenser, the path lengths and the mean losses by absorption and refraction in these zones for the absorption co-

efficients 1.3% and 3.9% per cm., which are about the limit values for glasses available for this purpose. Figure 128 illustrates approximately the paths of the rays representing the middle of the zones through the condenser.

The same is done in the next two tables for a Fresnel lens, which is spherically corrected, has only 2 reflecting surfaces, less glass path, but higher angles of incidence in the outer zones. The average glass path is here the same for all zones and equals 10 mm.

Loss of light on a concave silvered glass mirror as used behind the light source is caused.

(a) By the reflection of the in and out going ray on the outside surface, which amounts to about 8%,

(b) By reflection on the silver film, which varies considerably with the quality of silvering, 10% being an average figure, and

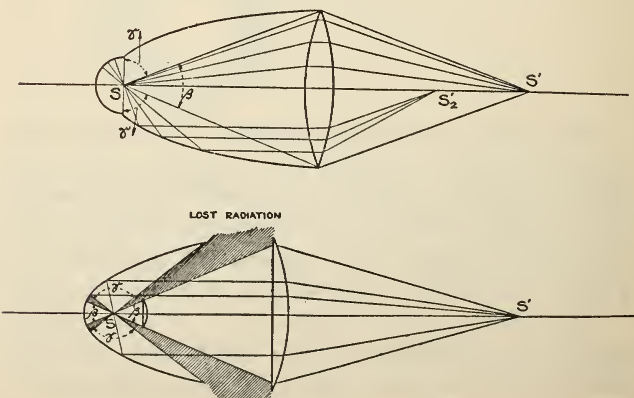


FIG. 129

SPHERICAL DOUBLE CONDENSER

Absorption Coefficient 1.3% per cm.

Distance of center of zone from opt. axis	Loss in % by reflection on surface				Loss in % by absorption and length of path in lens in (mm)		Sum of losses %	Loss in % in zone
	1	2	3	4	I	II		
5	4.4	4.1	3.9	3.6	(22.5) 2.7	(19.4) 2.1	20.8	1.3
15	4.4	4.1	3.9	3.6	(21.7) 2.6	(18.0) 1.9	20.5	3.9
25	4.4	4.2	4.0	3.7	(18.4) 2.3	(15.0) 1.6	20.2	6.3
35	4.8	4.5	4.2	4.0	(14.9) 1.9	(9.7) 1.1	20.5	9.0

Total Loss 20.5%

Absorption Coefficient 3.9% per cm.

Distance of center of zone from opt. axis	Loss in % by reflection on surface				Loss in % by absorption and length of path in lens in (mm)		Sum of losses %	Loss in % in zone
	1	2	3	4	I	II		
5	4.2	3.8	3.7	3.3	(22.5) 8.2	(19.4) 5.9	29.3	1.8
15	4.4	3.8	3.7	3.3	(21.0) 7.7	(18.0) 5.5	28.4	5.3
25	4.4	3.9	3.8	3.5	(18.4) 6.9	(15.0) 4.7	27.2	8.5
35	4.8	4.3	4.1	3.7	(14.9) 5.5	(9.7) 3.2	25.6	11.2

Total Loss 26.8%

(c) By the absorption in the glass which amounts to from 1% to 4% for a mirror of 5 mm. thickness.

These figures add up to a total loss of about 20% on the mirror. If photometric measurements show in general a greater loss up to 50% in commercial mirrors, the reason may be found in most cases in the poor silvering and bad conditions of the surfaces.

In the case of a double condenser about 73% to 80% of the light contained in the angle *2u* reaches the image of the source after having passed through the condenser. Of the 80% which in the best case is reflected by the spherical mirror, 20% to 27% are lost by passing the condenser so that the total amount which reaches the image of the source equals in the best case 80% + 64%, or 1.44 times the amount contained in the angle *2u*. If the higher figure for the loss in the condenser is taken, the total is reduced to 73% + 58% or 1.31.

In case of a single condenser the corresponding figures will be 1.58 and 1.53.

The question may now be raised what, is the best result obtainable at the present state of the art and in which directions may improvements be made.

We found the following factors of influence upon the efficiency of the condenser system:

(1) Radiation from the source not intercepted by the optical system and, therefore, lost;

(2) Spherical aberration of the condenser;

(3) Chromatic aberration of the condenser;

FRESNEL LENS

ABSORPTION COEFFICIENT 1.3% PER CM

Distance of center of zone from opt. axis	Loss in % by reflection on surface		Loss in % by absorption and length of path in lens in (mm)	Sum of losses %	Loss in % in zone
	1	2			
7.1	4.3	4.1	(10.0) 1.2	9.7	1.1
22.0	4.8	4.5	(10.0) 1.2	10.5	2.8
29.8	6.0	4.5	(10.0) 1.2	11.7	3.3
37.6	9.0	4.5	(10.0) 1.2	14.7	5.0

Total Loss 12.2%

ABSORPTION COEFFICIENT 3.9% PER CM.

Distance of center of zone from opt. axis	Loss in % by reflection on surface		Loss in % by absorption and length of path in lens in (mm)	Sum of losses %	Loss in % in zone
	1	2			
7.1	4.3	3.9	(10.0) 3.8	12.0	1.4
22.0	4.8	4.3	(10.0) 3.5	12.8	3.4
29.8	6.0	4.3	(10.0) 3.7	14.0	3.9
37.1	9.0	4.3	(10.0) 3.6	16.9	5.8

Total Loss 14.5%

(4) Diaphragm action (I) of the aperture plate on account of the rectangular shape of the opening;

(5) Diaphragm action (II) of the aperture plate on account of its location when the light source is not point-shaped;

(6) Absorption and reflection.

Of these the influence of (3) and (6) can be shortly dealt with. Chromatic aberration causes no loss of light in a properly designed system, while the loss by absorption and reflection which amounts to from 12% to 15% in single lens condensers and to 20% to 27% in doublets is absolutely unavoidable.

The loss due to the rectangular shape of the stencil, diaphragm action (I), cannot be avoided even by employing an optically perfect condenser and a point-shaped source and so there remain for consideration only the utilization of the radiation not intercepted by the condenser lens, the spherical aberration and the diaphragm action (II) of the aperture plate when the source is not point-shaped.

In figure 129, s is the source placed in the center of curvature of a hemispherical mirror, which throws all the light radiating in the direction away from the condenser back into the source. At its equator the hemispherical mirror is joined coaxially by a paraboloid which collects the rays of the solid angle B and sends them in a direction nearly parallel to the optical axis towards the condenser lens which forms an image of the source at s'.

All the light radiation within the solid angle *B* passes after reflection by the mirror through the condenser lens to the image point *s′* while the light radiating in the remaining solid angle *d* passes through the condenser lens directly, forming another image of the source at *s′*. The drawback of the construction lies in the technical difficulty of producing a perfect paraboloid and joining the two mirrors so that no shadow is cast within the cone and in the fact that two images of the source are produced. A paraboloid with badly-formed surface and also a decentration of the two mirrors are apt to cause uneven distribution of light in the cone even when the stencil is located near the lens. This apparatus may work well when used for lantern slide projection, but hardly for M. P. projection. Whether its efficiency is greatly superior to a good condenser made up of lenses in the usual way is somewhat doubtful if we consider the loss by reflection on the parabolic mirror and the fact that the greater part of the radiation is reflected by the hemisphere and then reflected by the parabolic mirror and, therefore, will suffer this loss twice.

Because of the similarity with Petzval's construction, we may mention here another one, which had been quite in vogue as an automobile headlight a few years ago. It contains (Fig. 129) a small condenser in whose focal point the source is placed and the usual arrangement of the concave mirror. The angle taken in by the condenser *B* and which is, at least, geometrically speaking, doubled by the mirror, amounts to about 50 degrees. This is thrown for-

ward by the condenser in a beam of parallel rays by the condenser. A paraboloidal reflector is joined coaxially with the spherical mirror, so that its focal point coincides with the focal point of the lens and the center of curvature of the spherical mirror. This paraboloid intercepts the greater part of the radiation which is not used by the lens and spherical mirror and like the condenser lens, projects it forward in a parallel beam. By adding a condenser lens of the diameter of the reflector, an image can be formed of the source not far from the condenser and the combination be used for projection work. A similar effect can be produced by moving the source and the center of the spherical mirror outside of the paraboloid and the condenser. The shape of the reflector should, however, be ellipsoidal in this case to prevent spherical aberration, which on account of the large angles of incidence near the margin of the reflector may reach enormous amounts. The combination produces one image of the source only when the focal points of the condenser and paraboloid coincide. Efficiency of this construction when used as motion picture condenser exists, probably, not even on paper. The spherical aberration can be partly avoided. The centering of such a combination upon a common optical axis is not at all an easy matter, and the lack of centering will cause a one-sided, uneven distribution of light.

The spherical mirror behind the source is undoubtedly a valuable addition. It dates back to the early days of the magic lantern. I used it in 1908, in an apparatus for the projection of compass readings on ships in combination with an in-

candescent lamp. The filament in these lamps, which were made by the Westinghouse Electric Co., was of grid form and resembled a very steep "M" with rounded corners, over which the image superimposed itself like a "W", so that no screening of the image by the source took place, except in one point at each bend. The device was patented.

In 1917, the General Electric Co. secured a patent on a modification of this arrangement, limiting it to a parallel coil grid filament, "the area of the spaces between the coils" being equal to the "effective light emitting area of the grid coils," which is the form now so frequently used.

As mentioned above, the gain by the use of the mirror behind the source amounts to 50 to 75 per cent.

The influence of the spherical aberration can be offset by placing the stencil near the condenser, which is equivalent to a lantern slide arrangement in reduced size. While the condenser could be of the most common kind, it would be necessary to place the source nearer the condenser, than so far has been feasible at least with sources of considerable area. There would be no loss by diaphragm action (II) of the aperture plate. The condenser could, however, not be of the Fresnel type, otherwise the circles separating the zones would be projected into the image as shadows.

A condenser without spherical aberration has the advantage that the stencil may be placed anywhere in the cone, except in a condenser of the Fresnel type, where location near the condenser

has to be avoided because of the shadows cast by the rings between the zones.

If the light source is point-shaped, no diaphragm action (II) by the aperture plate will occur wherever the latter may be placed. Diaphragm action (II) by the aperture plate will occur as soon as the light source has an extended area and as soon as the stencil is placed at a distance from the condenser.

A condenser without spherical correction, combined as usual with an extended source, is the least efficient combination, because of the position of the stencil necessitated by the uneven illumination of the cone and the resulting diaphragm action (II) of the aperture plate.

Bearing in mind, that the concave mirror renders the same service in all cases and that the condenser which is composed of the smaller number of elements is preferable and that the stencil is located in the smallest section of the cone where it is evenly illuminated we sum up the different possibilities in the sequence of their efficiency.

(1) Small ordinary condenser, source not too large and near the condenser, stencil near the condenser, large projection lens.

Practical difficulties: the light source. Faults: none.

(2) Just as good: large spherically corrected condenser, point-shaped source at usual distance from condenser, stencil not near the condenser, small projection lens.

Practical difficulties: the light source. Faults: none.

(3) Spherically corrected condenser, extended light source at usual distance from condenser,

stencil not near the condenser, large projection lens.

Practical difficulties: none. Faults: loss by diaphragm action (II) of the aperture plate.

(4) Large ordinary condenser, extended light source at usual distance from condenser, stencil not near condenser, large projection lens.

Practical difficulties: none. Faults: loss by spherical aberration and diaphragm action (II) of the aperture plate.

The nearer point-shaped the light source, the lower grade a projection lens may be used.

The Gundlach-Manhattan Optical Co., makers of the Gundlach Projection Lens, issue the following data regarding Lenses.

The manufacture of lenses presents many difficult problems for the optician to contend with because of the peculiar characteristics of optical glass as well as the fact that it is not a material easily worked owing to its hard, brittle nature. To produce lenses that are well corrected in the optical sense and maintain a uniform standard of quality requires not only scientific knowledge of optics and mathematics of a high order to compute the formula but also the utmost skill and precision must be used during the mechanical operations to obtain the desired result. Even then it depends upon a master optician for the final adjusting and testing before the lens is ready for market because a good lens may be spoiled by improper mounting. In this respect lenses are different from articles made of other materials which can readily be made to conform to dies, patterns

or blue-print specifications with certainty that when these are followed, the finished article will be perfect.

Each lens goes through several operations of grinding and polishing and a stray bit of grit may scratch a finished surface at the last moment, or lenses will crack or chip in handling, adding spoilage to the cost of manufacture.

A Projection Lens contains three distinct kinds of glass, each lot of glass has slightly different properties and as one melt never includes more than a few hundred pounds this necessitates a constant modification of formulae with a corresponding changing of tools which involves a big expense.

All this, of course, applies to a maintenance of a standard of quality and explains why ordinary projection lenses made with no special care and taken as they come naturally cost a great deal less than Gundlach Projection Lenses which must all pass the same tests and reach a fixed standard of quality before leaving the factory. Further, lenses of large aperture require more care in grinding and polishing than lenses of less curvature and their adjustment is more sensitive. Besides, the larger lenses must be made separately while those of smaller diameter with flatter surfaces can be made two or more at a time, reducing the cost of manufacture proportionately.

It is an axiom of optics that the best lens is never too good for the purpose and this is particularly true as regards projection, it being obvious that a poor lens makes a picture which is unsatisfactory to a large number of people and

the theatre owner or producer suffers in consequence by criticism of the show and loss of business. Now a poor lens not only will not focus sharply but the image is flattened and lacks contrast because what should be black becomes gray and light and shade gradations of the film image are not reproduced in their proper values.

Gundlach Projection Lenses on the contrary give uniformly sharp definition with the utmost illumination and the picture is brilliant because all the contrast of the film is preserved while the shadows show more detail due to the additional light obtained by their large working aperture.

THE SCREEN PICTURE

The size of the film image is ¾x 1″ and the opening in the aperture plate has been standardized by the principal machine manufacturers at our suggestion and is now 29/32″ wide with the height ¾ of the width. The picture is magnified in the same proportions; therefore the screen must be 9 inches high for each foot in width. For example, 9′x12′, 10′6″x14′ or 12′x16′. A picture 16 feet wide requires a magnification of the film image of about 212 diameters or nearly 44,944 times the size of the original.

The importance of standardization of the opening in the aperture plate may be realized from the fact that the two sizes formerly used 15/16″ wide and 29/32″ wide with a difference of only 1/32″ would result in a difference of about 6 inches between the width of pictures made with matched lenses for a picture 16 feet wide so that pictures of the same size could be obtained only by using

lenses of different focal lengths, an inconvenient and difficult method of securing this result.

It is our opinion that the quality of the picture is more important than its size, or, in other words, we must have perfect projection as the first consideration. Owing to the unavoidable loss in definition and illumination incidental to an increase in magnification it is advisable to keep the size of the picture within a reasonable limit which we think is about 12x16. Above this size the surface area increases very rapidly with each additional foot in width. The distance the picture is projected is not so important unless it necessitates the use of lenses of abnormally short or long focus.

Theoretically, there is a loss of light in inverse ratio to the square of the distance, but in practice a picture of a given size can be projected within a reasonable distance without any noticeable change in luminosity. Obviously this imposes a limitation to the size of theatres, therefore it is not advisable to make a theatre so large that good projection cannot be secured. The best results are obtained with lenses ranging between 4-inch and 7½-inch focal length and any deviation from these is not advisable.

The picture is projected from the same film whether it is thrown 25 feet or 150 feet, while an enlargement of the picture is secured only by magnification of the film image with a consequent depreciation of the light by spreading it over a greater surface. The definition is impaired as the natural result of magnifying a film image which is not absolutely sharp to begin with. On the contrary, a difference in the distance does not bring these factors into consideration although other

difficulties arise if an effort is made to produce too large a picture with a very short focus lens or a comparatively small picture with a relatively long focus lens. The thing to avoid is extreme or abnormal conditions because the best result can be obtained only by being careful that each factor having an influence upon the quality of the picture is normal and efficient. Most important of

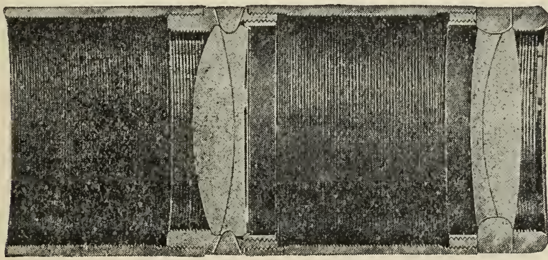


FIG. 130
Snaplight Lens

these is Gundlach Projection Lenses which insure uniform definition with a brilliant image and the utmost luminosity. We differentiate between brilliancy of the image and the working aperture of the lens or the amount of light it collects and transmits because the former is determined by its color correction which if good will preserve the contrast of the film and if poor will flatten the image while luminosity is merely the inevitable result of making the diameter large in proportion to the focal length.

Three principal factors govern the illumination of the picture, first the light source including its

adjustment, current consumption and condenser system by which the film is illuminated.

Next is the working aperture of the projection lens or the ratio between its diameter and focal length.

The third is the size of the picture or its surface area.

The working aperture of the lens is the only one in which we are directly interested.

This ratio in Gundlach Projection Lenses is carried out to the highest degree with resulting apertures of F.2. to F.3.5. according to the focal length is not being practical for many reasons to maintain a uniform aperture of F.2.

That the size of the picture is an important consideration is evident as it must be clear that the same amount of light spread over a larger surface will be weaker.

For comparison we give the following examples:

Size of Picture	Surface Area	Magnification
9x12	108 sq. ft.	158.88 diameters
12x16	192 sq. ft.	211.84 diameters
15x20	300 sq. ft.	264.80 diameters

THE PROJECTION LENS

This we have already mentioned as being the ratio between the diameter and focal length and this determines the amount of light transmitted by lenses of all kinds. Obviously there must be a physical limitation to this and in practical optics this is 1—2, so the diameter cannot be more than half the focal length. Even to attain this result is an achievement, it involves making lenses with

strong curves, each made separately with the utmost care and great precision in mounting and the adjustment of the components of the complete lens in relation to each other.

This means the distance from the optical center of the lens to the point where it defines a sharp image when focused for infinity and this measurement can be made accurately only by optical means. Commercially we grade the focal lengths in quarter inches in engraving the cells but we mark the exact focal length in hundredths of an inch on the wrapper and use this measurement in filling orders.

To cite an instance, a 16-foot picture at 99 feet requires a lens of 5.60 focus. A lens of exactly 5½-inch (5.50) focus would make the picture oversize and 5¾ focus would be too long. To meet this condition, we would make a selection from 5½-inch lenses in stock of those the nearest to 5.60-inch focus but longer rather than shorter. Of course there is a possibility in every case that an error in measuring the distance will be a disturbing factor and some allowance should be made by the customer for some difference between the size of the picture and screen which is unavoidable and easily painted out.

Lenses are matched by selection as the focal length cannot be modified after they are finished. In manufacturing they deviate to some extent from the focal length prescribed by the optical formula running both under and over for which reason they are not necessarily the exact focal length engraved upon the mounts. For example, a 4-inch lens may vary within the quarter inch from 3.95 inch to 4.20 inch, it being our practice to

mark the amounts within 5/100 inch under to 20/100 inch over the actual focal length and it will be perceived that two lenses marked with the same focal length may at the most have a difference of ¼ inch and matching for pictures of the same size necessitates that both lenses shall be exactly the same focal length. This being the case the lenses must be matched when they leave our factory unless a lens to be duplicated is sent to us so we can measure it or if it was purchased from us we will have a record of its focal length which we can locate if given the order number or date of invoice. The exact focus in hundredths of an inch is shown by our invoices in parentheses, for example, (4.36), and purchasers should make a note of this to faciliate placing repeat orders for duplicates when they wish to match a lens or replace one which has been damaged.

This system has proved a great convenience to many of our customers and constitutes a real service which adds greatly to our detail in making and supplying lenses. Sometimes we are called upon to match or duplicate a lens we sold several months or years ago, and it is quite an advantage to the customer to get a new lens that will make the picture the same size it was before without any loss of time.

It should be noted by every user of a projection lens that the components are not interchangeable and no liberty whatever should be taken with the arrangement or adjustment of a lens. A broken element cannot be replaced unless the complete lens is returned for repairs and the broken parts should be preserved as they may be useful in determining the exact original focal length, other-

wise this may be changed by replacing the broken lens. Odd combinations or lenses are absolutely of no value and we cannot undertake to utilize them to make up complete lenses or for repairs.

The condition of many lenses sent in to us indicates great carelessness in handling them and Projectionists should be cautioned to handle them more gently. There is positively no excuse for so many scratched surfaces, broken lenses and ruined mounts after allowing for reasonable accidents.

The terms quarter and half size have no real place in optical nomenclature although commonly used. No doubt they originated in the early days of photography when applied to portrait lenses used for quarter size (3¾x4¼) and half size (4¾x6½) cameras. These were the first lenses used for projection and eventually each size was made in a number of different focal lengths. The Projection Lenses of to-day are made by a modification of the formula of the original Petzvel Portrait Lens which we have brought to perfection with the improved optical glass at our command. The sizes of Gundlach Projection Lenses are numbered to prevent them from being unfairly compared or confused with so-called quarter and half-size lenses of smaller diameter and less light efficiency.

We wish to make it clear that there is no optical difference between our No. 1 and No. 2 size Projection Lenses. The No. 2 size is merely a continuation of the No. 1 size, providing longer focal lengths with the same relative working aperture to maintain the illuminating power, but it is evident that in corresponding focal lengths the

No. 2 size will transmit more light than the smaller size, therefore, it is a decided advantage to use the No. 2 lenses in any focal length in which they are made from 5¾ inches up. If the increased illumination is not needed on the screen it can be saved in current so the lens of large aperture is an economy to this extent.

To answer a question frequently put to us, we state that the keystone effect incidental to projecting the picture from an angle can not be corrected by the Projection Lens, this being the natural result of a difference in the length of the light rays from the lens to the top and bottom or sides of the screen as the case may be, causing a greater magnification of the image at one point than at the other. Theatre architects should be informed that the location of the operating room should be planned to bring the machines in a horizontal line with the center of the screen.

In event that lenses we supply do not make the picture close enough to the desired size, on account of an error in measuring the distance, report at once the exact width of the picture they produce and we can then allow for the error and determine what the distance actually is and the focal length required.

If you want Gundlach lenses to make a picture the same size as it is made by some other lens send the lens to us to be measured because you cannot depend upon the focal length engraved on the mount.

COMPUTING THE FOCAL LENGTH

The focal length required is ascertained by a computation based upon the size of the opening in

the aperture plate, the size of the picture wanted and the distance it is to be projected.

The distance is somewhat uncertain owing to errors made in measuring it which we have known to amount to as much as fifteen feet, but in case a mistake has been made by which lenses of the wrong focus have been secured it is easily rectified. We should then be informed the exact width of the picture made by the lenses the customer has received and as we have a record of their exact focus, we can calculate from these two factors what the correct distance is and determine the proper focal length of the lenses to send in exchange. The distance of projection can be obtained by referring to the architect's plans of the theatre if these are available.

Measure the distance accurately, and you can depend upon us to supply lenses of the correct focal length.

CLEANING AND ASSEMBLING

First note whether the extension tube is attached to the front or rear end so you will replace it correctly. Clean both sides of the front combination but do not remove it from the cell. To remove the retaining ring from the rear cell, press lightly on opposite sides of the ring with two fingers and unscrew it. Too much pressure will make it bind so it will not turn. Clean inside surfaces of the two lenses of the rear combination and replace in the cell. Be careful they are seated evenly, then screw up the retaining ring just tight enough to prevent them from moving, then clean the outside surface.

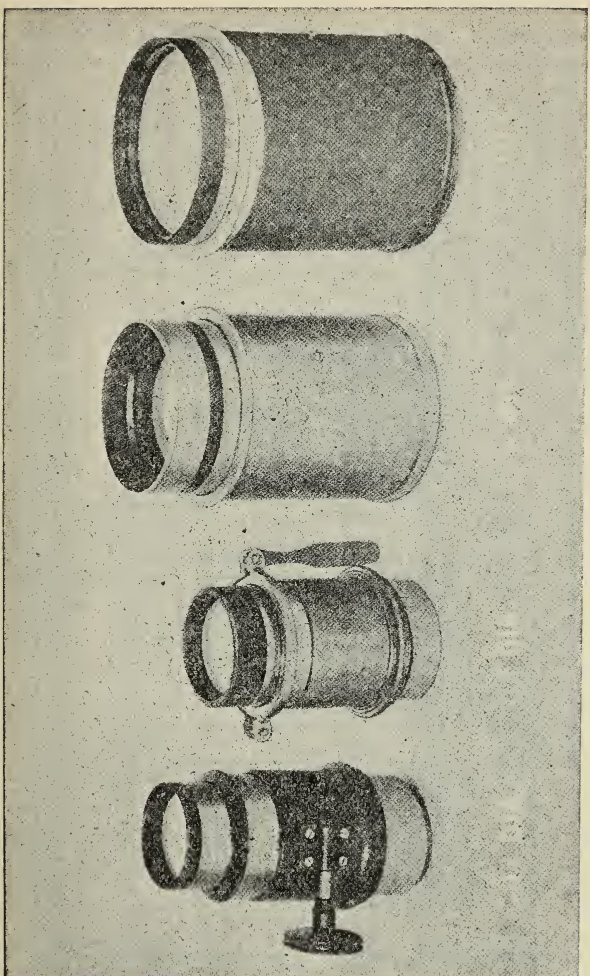
The rear lens is convex on both sides and the

flatter side is the outside rear surface. The retaining rings should face towards the center; reversing the cells will disturb the correction.

To remove grease or oil from the surface of the lens, use a soft rag free from grit, moistened with a little gasoline.

Be careful when screwing the parts together to avoid skipping a thread and do not screw up any joints very tight.

Do not use a hard sharp tool to remove the retaining ring or it may slip and scratch the lenses.



LENS TABLE OF FILM PROJECTION

DISTANCE FROM FILM TO SCREEN

Stero.	M. P.	15	20	25	30	35	40	45
8	2	5.04	6.74	8.44	10.14	11.84	13.54	15.24
		6.72	8.99	11.25	13.52	15.78	18.05	20.31
9	2¼	4.48	5.99	7.50	9.01	10.52	12.03	13.54
		5.97	7.98	10.00	12.01	14.03	16.04	18.05
10	2½	4.02	5.38	6.74	8.10	9.46	10.82	12.18
		5.36	7.17	8.99	10.80	12.61	14.42	16.24
11	2¾	3.65	4.89	6.12	7.36	8.59	9.83	11.06
		4.87	6.52	8.17	9.18	11.46	13.11	14.76
12	3	3.34	4.47	5.61	6.74	7.87	9.00	10.14
		4.46	5.97	7.48	8.99	10.50	12.01	13.52
13	3¼	3.08	4.13	5.17	6.22	7.26	8.31	9.35
		4.11	5.50	6.90	8.19	9.69	11.08	12.48
14	3½	2.86	3.83	4.80	5.77	6.74	7.72	8.69
		3.81	5.10	6.40	7.69	8.99	10.28	11.58
15	3¾	2.66	3.57	4.47	5.38	6.28	7.19	8.10
		3.55	4.76	5.97	7.17	8.38	9.59	10.80
16	4	2.49	3.34	4.19	5.04	5.98	6.74	7.59
		3.32	4.45	5.59	6.72	7.85	8.98	10.12
17	4¼	2.34	3.14	3.94	4.74	5.54	6.34	7.14
		3.12	4.19	5.25	6.32	7.38	8.45	9.52
18	4½	2.21	2.97	3.72	4.48	5.23	5.99	6.74
		2.95	3.96	4.96	5.97	6.98	7.98	8.99
19	4¾	2.09	2.81	3.52	4.24	4.95	5.67	6.38
		2.79	3.74	4.70	5.65	6.61	7.56	8.51
20	5	1.98	2.66	3.34	4.02	4.70	5.38	6.06
		2.64	3.55	4.45	5.36	6.27	7.17	8.08
21	5¼	1.89	2.54	3.18	3.83	4.48	5.13	5.77
		2.51	3.37	4.24	5.10	5.96	6.83	7.69
22	5½	1.80	2.42	3.04	3.65	4.27	4.89	5.51
		2.40	3.22	4.05	4.87	5.70	6.52	7.34
23	5¾	1.72	2.31	2.90	3.49	4.08	4.67	5.27
		2.29	3.08	3.87	4.65	5.44	6.23	7.02
24	6	1.64	2.21	2.77	3.34	3.91	4.47	5.04
		2.19	2.95	3.70	4.46	5.21	5.97	6.72
25	6¼	1.57	2.11	2.66	3.20	3.75	4.29	4.83
		2.10	2.82	3.55	4.27	5.00	5.72	6.45
26	6½	1.51	2.03	2.56	3.08	3.60	4.12	4.65
		2.02	2.72	3.41	4.11	4.81	5.51	6.20
27	6¾	1.45	1.95	2.46	2.96	3.46	3.97	4.47
		1.94	2.61	3.28	3.95	4.63	5.30	5.97
28	7	1.40	1.89	2.37	2.86	3.34	3.83	4.31
		1.87	2.52	3.16	3.81	4.46	5.11	5.75
29	7¼	1.35	1.82	2.29	2.76	3.23	3.69	4.16
		1.80	2.42	3.05	3.67	4.30	4.92	5.69
30	7½	1.30	1.75	2.21	2.66	3.11	3.57	4.02
		1.74	2.34	2.95	3.55	4.16	4.76	5.37
31	7¾	1.26	1.70	2.14	2.58	3.01	3.45	3.89
		1.68	2.26	2.85	3.43	4.02	4.60	5.19
32	8	1.22	1.64	2.07	2.49	2.92	3.34	3.77
		1.62	2.19	2.75	3.32	3.89	4.45	5.02
33	8¼	1.18	1.59	2.00	2.42	2.83	3.24	3.65
		1.57	2.12	2.67	3.22	3.77	4.32	4.87
34	8½	1.14	1.54	1.94	2.34	2.74	3.14	3.54
		1.52	2.05	2.59	3.12	3.65	4.19	4.72
35	8¾	1.11	1.50	1.88	2.27	2.66	3.05	3.43
		1.48	2.00	2.51	3 03	3.55	4.06	4.58

LENS TABLE OF FILM PROJECTION—*Continued*

DISTANCE FROM FILM TO SCREEN

Stero.	M. P.	50	56	60	64	70	76	80
8	2	16.93	18.97	20.33	21.69	23.73	25.77	27.13
		22.58	25.30	27.11	28.92	31.64	34.46	36.17
9	2¼	15.05	16.87	18.07	19.28	21.09	22.91	24.12
		20.07	22.48	24.10	25.71	28.12	30.54	32.15
10	2½	13.54	15.17	16.26	17.34	18.98	20.61	21.70
		18.05	20.22	21.67	23.12	25.30	27.47	28.92
11	2¾	12.30	13.78	14.77	15.76	17.24	18.73	19.72
		16.40	18.38	19.70	21.01	22.99	24.97	26.29
12	3	11.27	12.63	13.54	14.44	15.80	17.16	18.07
		15.03	16.85	18.05	19.26	21.07	22.89	24.10
13	3¼	10.40	11.65	12.49	13.33	14.58	15.84	16.67
		13.87	15.54	16.66	17.77	19.45	21.12	22.23
14	3½	9.66	10.82	11.60	12.38	13.54	14.71	15.48
		12.87	14.43	15.46	16.50	18.05	19.60	20.64
15	3¾	9.00	10.09	10.82	11.54	12.63	13.72	14.44
		12.00	13.46	14.42	15.39	16.84	18.29	19.26
16	4	8.44	9.46	10.14	10.82	11.84	12.86	13.54
		11.25	12.61	13.52	14.42	15.78	17.14	18.05
17	4¼	7.94	8.90	9.54	10.18	11.14	12.10	12.74
		10.58	11.86	12.72	13.57	14.85	16.13	16.98
18	4½	7.50	8.40	9.01	9.61	10.52	11.42	12.03
		9.10	11.21	12.01	12.82	14.03	15.23	16.04
19	4¾	7.10	7.96	8.53	9.10	9.96	10.82	11.39
		9.47	10.61	11.38	12.14	13.28	14.43	15.19
20	5	6.74	7.55	8.10	8.64	9.46	10.27	10.82
		8.98	10.07	10.80	11.52	12.62	13.70	14.42
21	5¼	6.42	7.20	7.72	8.23	9.01	9.79	10.30
		8.55	9.59	10.28	10.97	12.00	13.04	13.73
22	5½	6.13	6.87	7.36	7.86	8.60	9.34	9.83
		8.17	9.16	9.82	10.47	11.46	12.45	13.11
23	5¾	5.86	6.57	7.04	7.51	8.22	8.93	9.40
		7.81	8.75	9.38	10.01	10.96	11.90	12.53
24	6	5.60	6.28	6.74	7.19	7.87	8.55	9.00
		7.48	8.38	8.99	9.59	10.50	11.40	12.01
25	6¼	5.38	6.03	6.46	6.90	7.55	8.20	8.64
		7.17	8.04	8.62	9.20	10.07	10.94	11.52
26	6½	5.17	5.80	6.22	6.63	7.26	7.89	8.31
		6.90	7.74	8.39	8.85	9.69	10.53	11.08
27	6¾	4.98	5.58	5.98	6.38	6.99	7.59	8.00
		6.64	7.44	7.98	8.52	9.32	10.13	10.67
28	7	4.80	5.38	5.77	6.16	6.74	7.32	7.71
		6.40	7.18	7.70	8.21	8.99	9.77	10.28
29	7¼	4.63	5.19	5.57	5.94	6.51	7.07	7.44
		6.17	6.92	7.42	7.92	8.67	9.43	9.93
30	7½	4.47	5.02	5.38	5.74	6.28	6.83	7.19
		5.97	6.69	7.18	7.66	8.39	9.11	9.59
31	7¾	4.33	4.86	5.21	5.56	6.08	6.61	6.96
		5.77	6.48	6.95	7.42	8.12	8.82	9.29
32	8	4.19	4.70	5.04	5.38	5.89	6.40	6.74
		5.58	6.26	6.72	7.17	7.85	8.53	8.98
33	8¼	4.06	4.56	4.89	5.22	5.71	6.21	6.54
		5.41	6.07	6.51	6.95	7.61	8.27	8.71
34	8½	3.94	4.42	4.74	5.06	5.54	6.02	6.34
		5.25	5.89	6.32	6.74	7.38	8.02	8.44
35	8¾	3.82	4.29	4.60	4.91	5.38	5.84	6.15
		5.10	5.72	6.13	5.65	7.17	7.79	8.20

LENS TABLE OF FILM PROJECTION—*Continued*

DISTANCE FROM FILM TO SCREEN

Stero.	M. P.	84	90	96	100	104	110	116
8	2	28.49	30.53	32.57	33.93	35.29	37.33	39.36
		37.99	40.71	43.42	45.24	47.05	49.77	52.49
9	2¼	25.32	27.14	28.95	30.16	31.37	23.18	34.99
		33.76	36.18	38.60	40.21	41.82	44.24	46.55
10	2½	22.78	24.42	26.05	27.14	28.22	29.86	31.49
		30.37	32.55	34.72	36.17	37.62	39.80	41.97
11	2¾	20.70	22.19	23.67	24.66	25.65	27.13	28.61
		27.61	29.59	31.56	32.88	34.20	36.18	38.15
12	3	18.97	20.33	21.69	22.60	23.50	24.86	26.22
		25.30	27.12	28.93	30.14	31.35	33.16	34.97
13	3¼	17.51	18.77	20.02	20.86	21.69	22.95	24.20
		23.35	25.02	26.70	27.81	28.93	30.60	32.27
14	3½	16.26	17.43	18.59	19.37	20.14	21.31	22.47
		21.68	23.23	24.78	25.82	26.86	28.41	29.96
15	3¾	15.17	16.25	17.34	18.07	18.79	19.88	20.97
		20.22	21.67	23.12	24.09	25.06	26.51	27.96
16	4	14.22	15.24	16.25	16.93	17.61	18.63	19.65
		18.95	20.31	21.67	22.58	23.48	24.84	26.20
17	4¼	13.38	14.34	15.30	15.94	16.57	16.52	18.48
		17.83	19.11	20.39	21.25	22.10	23.38	24.66
18	4½	12.63	13.54	14.44	15.05	15.65	16.56	17.47
		16.85	18.05	19.26	20.07	20.87	22.08	23.29
19	4¾	11.96	12.82	13.68	14.25	14.83	15.86	16.54
		15.96	17.10	18.24	19.10	19.77	20.92	22.06
20	5	11.36	12.28	12.99	13.54	14.08	14.89	15.71
		15.15	16.23	17.32	18.05	18.77	19.86	20.95
21	5¼	10.82	11.60	12.38	12.89	13.41	14.19	14.96
		14.42	15.46	16.49	17.18	17.87	18.91	19.94
22	5½	10.33	11.07	11.81	12.31	12.80	13.54	14.28
		13.77	14.76	15.73	16.40	17.07	18.06	19.04
23	5¾	9.88	10.59	11.29	11.77	12.24	12.95	13.66
		13.16	14.11	15.06	15.69	16.32	17.26	18.21
24	6	9.46	10.14	10.82	11.27	11.72	12.40	13.08
		12.61	13.52	14.42	15.03	15.63	16.54	17.45
25	6¼	9.07	9.73	10.38	10.81	11.25	11.90	12.55
		2.10	12.97	13.84	14.42	15.00	15.87	16.74
26	6½	8.72	9.35	9.98	10.40	10.82	11.44	12.07
		11.64	12.48	13.31	13.87	14.43	15.27	16.10
27	6¾	8.40	9.00	9.60	10.01	10.41	11.02	11.62
		11.20	12.01	12.81	13.35	13.89	14.69	15.50
28	7	8.10	8.68	9.27	9.65	10.04	10.62	11.21
		10.80	11.58	12.36	12.87	13.39	14.17	14.94
29	7¼	7.82	8.38	8.94	9.32	9.69	10.26	10.82
		10.42	11.17	11.93	12.43	12.93	13.68	14.43
30	7½	7.55	8.10	8.64	9.00	9.37	9.91	10.45
		10.08	10.80	11.53	12.01	12.50	13.22	13.95
31	7¾	7.31	7.84	8.36	8.71	9.07	9.59	10.12
		9.76	10.46	11.16	11.63	12.10	12.80	13.50
32	8	7.08	7.59	8.10	8.44	8.78	9.29	9.80
		9.44	10.12	10.80	11.25	11.70	12.38	13.06
33	8¼	6.86	7.36	7.85	8.18	8.51	9.01	9.50
		9.15	9.81	10.47	10.91	11.35	12.01	12.66
34	8½	6.66	7.14	7.62	7.94	8.26	8.74	9.22
		8.88	9.52	10.16	10.58	11.01	11.65	12.29
35	8¾	6.46	6.93	7.40	7.71	8.02	8.48	8.95
		8.62	9.24	9.86	10.27	10.6	11.31	11.93

SCREENS

The screen has in the past been one of the most neglected features of the average picture theatre. He who states that this or that particular screen is the best in all cases is in the same class with the country fair medicine vendor who calmly proclaims that his pill has the virtue of curing all ills from mange to matrimony.

The sole duty of a screen is to reflect light. We see the picture on the screen not by the light that strikes the screen, but by the light which the screen reflects to the eye. We would not be able to see a picture projected onto a black screen, for the simple reason that there would be no light reflected. Then again, the screen that reflects the most light need not necessarily be the ideal screen, the manner in which the light is reflected must be taken into consideration.

There are so many things to consider when choosing a screen for any particular installation that it is almost impossible to give general information that can be applied without qualification. The following are a few of the points that should be considered:

Size and shape of theatre.

Is there a balcony?

Location of the projection room in relation to the screen.

Layout of seats as regards the viewing angle.

Is the screen to be fixed or movable, and is there to be light behind it at times?

Distance from screen to nearest row of seats.

Kind and quantity of light to be used in projector and its source.

Some further points to be borne in mind are these: No screen reflects all of the light that reaches it because all materials are more or less absorbent. No screen can be an efficient direct reflector and at the same time a satisfactory diffuser of light, as these two qualities are in direct opposition. In referring to the two classes of screens, it would probably be better to speak of one as a direct reflector and the other as an indirect reflector.

With a given source of light projected at normal, i. e., from directly in front and viewed from the same position, the direct reflecting screen will be much brighter than the indirect reflecting one, but when viewed from angles the indirect reflector is the brighter, the difference increasing as the angle increases. To the observers seated rather close to the screen of average size the picture will be more satisfactory if an indirect reflector is used, because the viewing angle varies considerably for different points on the screen, and consequently the picture would not be of uniform brightness if a direct reflector were used.

Generally, the direct reflecting screens are metallic surfaced (there are a few exceptions), while the indirect reflectors have a non-metallic (mineral or fabric) surface. Metallic surface screens generally show very contrasty pictures, the high lights being very bright and glary, and

the shadows very deep. There is a lack of graduation in the toning, however, so that the picture is deficient in fine detail. The indirect reflectors on the other hand are generally not contrasting because their high lights are subdued, i. e., not glary, and the shadows are not so deep or black but the picture is full of half tones, the fineness of which depends largely upon the grain or weave of the material used and its uniformity.

The maximum in screen value may be summed up as follows:

Most light from given current consumption or high reflection and slight absorption of the incident light. Uniform distribution of the reflected light over a wide angle without loss of brightness. Detail and half tones without diminishing contrast clear, bright "high lights" without glare, absolute opaqueness, great durability and ease of transportation and installation, adaptability to different light sources, such as arc or incandescent lamps, direct or alternating current.

Since all of these features cannot be incorporated in any one screen, it becomes necessary to decide which one has the best combination of the above mentioned points in accordance with the requirements of the auditorium being equipped. While the writer has never made a thorough test of the matter, he is of the opinion that it is unwise to attempt to decide the amount of current necessary for a given installation by considering only the seating capacity of the house and the size of the screen. The shape of the auditorium and the arrangement of the seats in relation to the screen are matters of the utmost importance when con-

sidering not only the amount of illumination necessary but also the kind of screen upon which the light is to be projected, because if the room be wide in proportion to the depth or there is a

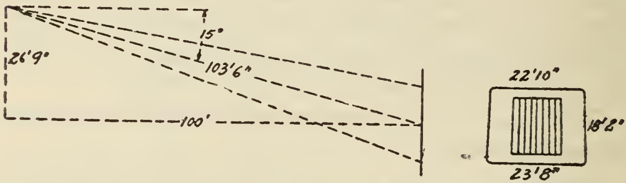


FIG. 131

deep balcony with the projection room at a considerable elevation, so that there are some seats from which the viewing angle is greater than 20 or 25% of either the axis of projection or of the perpendicular face of the screen, or both, it will be necessary to install a screen of the indirect reflecting type so that the illumination will be distributed over these wide angles, and since distributing a given amount of light over a

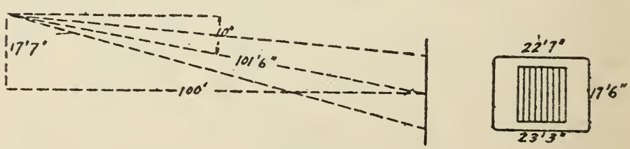


FIG. 132

greater area proportionately reduces the amount of light available *per degree,* it will be necessary, if a given screen brightness is to be maintained, to use more current in a house having rather large

angles than would be used if the angles were not so great. This does not necessarily mean that as generally used one class of screen is more costly in the matter of current than the other. It all depends upon whether or not the screen is suited to the house. If, for instance, an indirect reflecting screen is installed in a long, narrow house, a large proportion of the light will be reflected toward the side walls and ceiling and wasted. On the other hand, if a direct reflector screen be installed in a house that is rather wide or where the

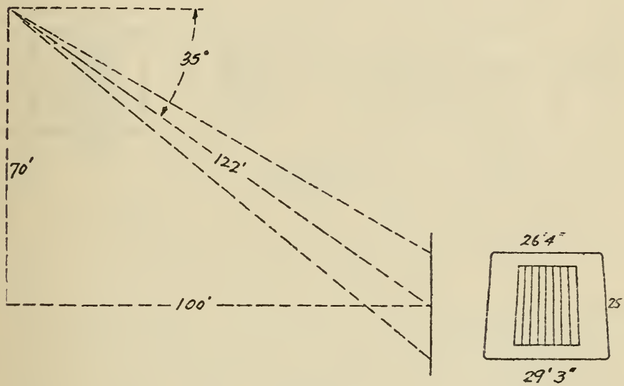


Fig. 133

picture is projected at an angle, there will be a pronounced "fade-out" or loss of light from all seats that are not in the direct reflective angle of the screen. Now, in order to overcome the fade-out and increase the light to seats outside of this direct reflective angle, the projectionist usually increases the incident illumination to a degree far beyond the amount needed for proper screen

brightness, a practice that is not only wasteful as regards electric current, but produces the glare in the "high lights" that is extremely unpleasant to the observer as well as injurious to the eyes.

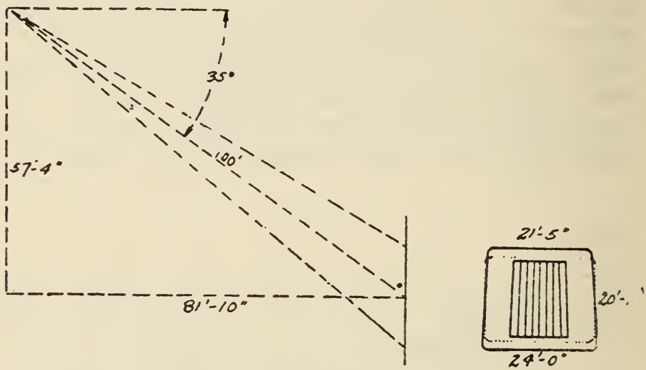


FIG. 134

LIGHT INTENSITIES FOR MOTION PICTURE PROJECTION

From the standpoint of their reflection characteristics, screens in common use may be divided into two classes:

Diffuse reflecting screens;

Spread reflecting screens.

Of the first class, white cloth screens and plaster screens are typical. A white cloth screen when clean can be made to reflect as high as 70 to 75% of the light which strikes it; and a plaster screen 80 to 88%. The light is reflected at wide angles, as shown in the slide. Such screens are well adapted to theatres in which the position of the seats with respect to the screen is such that the picture must be viewed at relatively large angles, for no matter from what angle the screen is viewed, the brightness is the same because of the way in which the light is reflected.

Aluminumized screens and ground-mirror screens are examples of the spread reflecting class. A clean aluminumized screen can be designed to reflect about 60 to 65% of the light striking it and will confine the reflected light within an angle of approximately 30°. Ground-mirror screens when clean can be made to reflect approximately 80 to 90% of the light and confine the light within about 30°. Such screens are well adapted to theatres in which the seats are so arranged that the picture does not have to be viewed at large angles.

Thus it is seen that the intensity of the beam projected determines only relatively the brightness of the picture.

Uniformity of screen illumination is another factor which must be considered in connection with screen intensities. It is not uncommon to find screens upon which the intensity near the center is several times the intensity near the edges of the picture, or where the intensity on one-half of the screen is much higher than upon the other

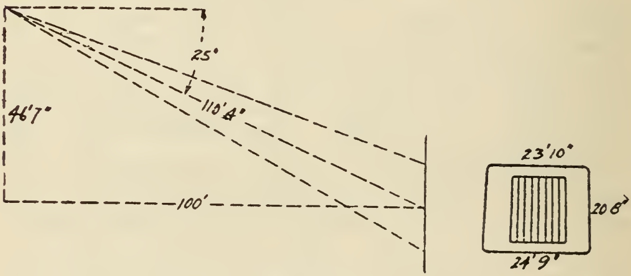


Fig. 135

half. When this condition of non-uniformity obtains, certain portions of the picture are, of course, brighter than others, and while the eye cannot readily detect small differences in brightness, the fact remains that to say a screen is illuminated to a certain average intensity is not definite when a wide difference exists between minimum, average and maximum intensity values. Good projection requires a screen intensity approaching uniformity, and the nearer the intensities at different points come to being equal the better will be the projection from this standpoint. The uniformity

of intensity at different points on the screen is affected by the condenser design, steadiness of the light, and by refinement in focusing adjustment.

Another factor which we must consider is extraneous light. Obviously a higher screen intensity is required in a theatre in which daylight is allowed to enter or where lights are kept burning at all times than in one where all the light comes only from the projection apparatus. The effect of extraneous light is to decrease the con-

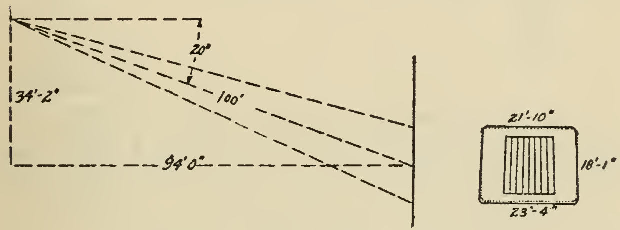


FIG. 136

trast between the high lights and the low lights on the screen. If for example the intensity of the beam in a low light of the film is, say, 1/50 of a foot candle at the screen, and in high light the intensity is, say, 2 foot-candles, the contrast is 1 to 100. If upon the screen image is now superimposed an intensity of 1/10 of a foot-candle, due to extraneous light, the contrast becomes approximately 1 to 17. From this it is apparent that even a very low intensity of extraneous light calls for considerable increase in screen intensity if good contrast is to be secured.

Before leaving the subject of contrast, I wish

to mention that film producers are endeavoring to a greater and greater extent to provide the proper degree of contrast in their films. More and more care is given to lighting scenes in such a way that with a projecting beam of normal intensity the proper graduations of light and shade will appear on the screen.

The use of tinted and toned film is becoming more extensive. This tinting and toning serves two purposes—it lends color to the scene, and it reduces the intensity. Usually, the producer has

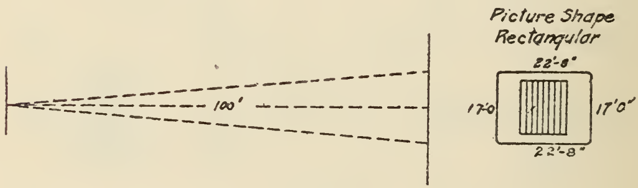


FIG. 137

both of these effects in mind. He uses a blue tone, let us say, to portray a moonlight scene. The color gives the observer an impression of moonlight; the producer intends in all probability that the low intensity shall help in furthering this impression. If, then, the operator, seeing that the picture is not perfectly clear, sends a rush of extra current through his carbons, he kills to an extent the impression that the producer hoped to convey. I have talked with producers who considered this natural tendency of the operator to be a matter worthy of no little consideration.

Data which I have obtained on the transmission of samples of tinted film may be of interest.

Absorption of Light by Various Tints of Films.

Film.	Per cent of Absorption.
Blank	9%
Yellow	21%
Light Amber	22%
Heavy Amber	33%
Light Blue	33%
Dark Blue	40%
Green	53%
Purple	62%
Orange	67%
Red	79%

The illumination on the screen with the shutter stationary and no film in the machine has been taken as 100%. The values for the tinted samples are given in percentage of light absorption due to the different tints. The values given in the table represent tests on a single sample of each tint and while these samples are believed to be typical others might of course show somewhat higher or lower values.

In view of the foregoing general discussion you will not be surprised when I say that suitable intensities for motion picture projection range probably from as low as 2.5 foot candles to as high as 30, depending upon local conditions. I do not think that 2.5 foot-candles is sufficient for the projection of a dense film on a dusky muslin screen; neither do I think that an intensity as high as 30 foot-candles is desirable for a light film projected on a highly selective or spread re-

flecting screen. I know of cases where theatre managements have been forced, through the complaints of their patrons, to reduce the intensities they were employing from a value near the upper limit of the range I have given to a considerably lower one. If muslin or plaster screens are used, and these are faithfully kept clean, I believe an intensity of 5 foot-candles should be ample for the proper projection of all except very dense films. If an aluminumized or a ground-mirror screen is employed a value of 2½ foot-candles should be ample. A great many theatres are projecting pictures with less than 3 foot-candles, using a plain screen, while one of the largest and best known theatres is obtaining less than 10 foot-candles on a plain screen. The distinction between dense films and tinted and toned films is of interest. In the former, the density is due to variation in exposure and development and is not as a rule obtained with definite purpose; in the latter, the purpose is to lend color to the picture and to control its brightness. I believe that an intensity of 5 foot-candles on any good, clean screen will be sufficient for the projection of any film sent out by a competent producer, and I also believe that no discomfort will be experienced from intensities in the neighborhood of 10 foot-candles. In giving these values I presuppose the intensity due to the general illumination of the theatre to be of a very low order and assume the measurements to be made with the shutter open and no film in the machine. As I have previously mentioned, the effect of extraneous light in decreasing the brilliancy of a picture is very marked.

The light intensity at the screen with any system is of course dependent upon the light given off by the source, and with both arc lamp and incandescent lamp systems the light which the source gives off is dependent, but not in equal ratio, upon the current which flows. The intensity on the screen can, then, be controlled within limits by the current which is forced through the source. The condensers in all arc lamp systems must be located at a considerable distance from the source, chiefly because of the intense heat of the arc, and manufacturing considerations limit the sizes of condensers to the point where, as you will note, the angle or zone subtended by the condenser with respect to the arc is small. With direct-current arcs this is not so great a handicap as with alternating-current arcs, for the direct-current arc throws the greater portion of the light it generates forward. The objectives used with arc lamp equipment are made small in diameter with respect to their focal length in order that irregularities in the arc will not be annoyingly apparent on the screen. There is a possibility of increasing the screen intensity with arc lamp apparatus by increasing the aperture of the objective lens, but under present conditions such an increase would be likely to be obtained at a sacrifice of steadiness in the picture. There seems to be a possibility of increasing the intensity produced by direct-current machines by more careful design of

the shutter and possibly by rotating the shutter at higher speeds. It is doubtful if the shutters of alternating-current machines can be much improved because the cooling of the carbons is so rapid that a stroboscopic effect is likely to be encountered. This effect is, of course, marked at present where 25-cycle current must be used.

A mirror can be used to redirect into useful directions the light which the lamp gives off in directions away from the condenser. The use of this mirror increases the illumination on the screen by approximately 75%. The lamp is so designed that relatively little light is thrown off to the sides, that is, a relatively large part of the light either strikes the condenser directly or indirectly by reflection from the mirror. The fact that the light source is confined within a bulb eliminates danger of cracking the condenser; hence, a short-focus condenser which subtends a large angle can be utilized. Through the design of a special prismatic condenser, the necessity for a thick and heavy lens with accompanying aberration is obviated. The fact that the light source is absolutely steady and without noticeable flicker, even on 25-cycle current, permits the use of a wide aperture objective lens with an accompanying good utilization of light. Shutters can be designed to operate very effectively with incandescent lamp equipment because of the fact that the filament, being heavy, does not get a

chance to cool between current reversals. When arc machines are being adapted to the incandescent lamp, it is of advantage to bear the point in mind that the shutter can usually be improved. It is due solely to the better utilization of light that the incandescent lamp, a source of lower brilliancy and far less energetic consumption than the arc, can be used to project satisfactory motion pictures.

For many years the arc lamp has been practically the only light source used in motion-picture projection work and higher and higher amperages have been employed as the size of theatres has increased and as competition between theatres has become keener. It appears that a reaction from the very high values may be logically expected, for a brilliant picture loses its attractiveness when discomfort and eye strain from glare is experienced. A bright screen viewed against a dark background produces an effect similar to that produced by a bright street light viewed against its background. In the first case the effect is less marked and may not be attributed to contrast in brightness, and for this reason is probably more serious than as if the trouble were recognized at once and corrected.

The screen should be outlined with a dull black border, and should be placed so that no light save the light from the projector reaches it. The location of the screen must be governed by local con-

ditions, but it is well to see that it is placed high enough so that the lower part of the picture can be comfortably seen in all parts of the house, and yet not so high that those sitting down front have to strain their neck looking up to the picture. Wherever possible the screen should be placed so that the center beam of light strikes the center of the screen at right angles. By doing this distortion and "keystone effect" will be overcome.

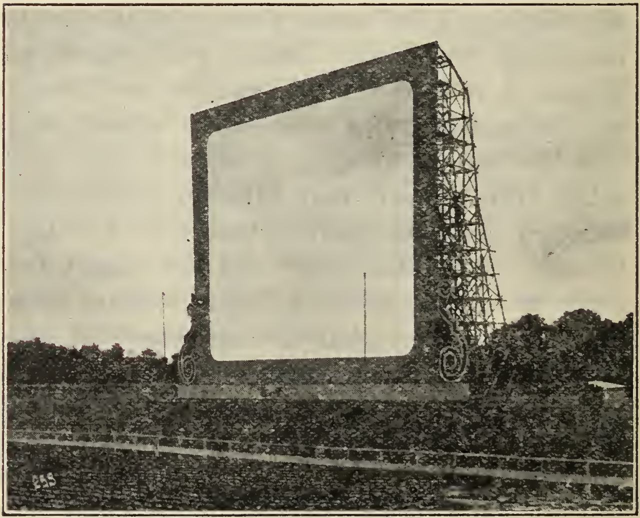


Fig. 138

REFLECTION CHARACTERISTICS OF PROJECTION SCREENS

When it is considered that the enjoyment of the entertainment offered in the motion picture theatre depends almost entirely upon the visual organs, it will be recognized that the importance of providing conditions which will result in the least possible visual fatigue to the audience cannot be overestimated. There are many factors which deserve the consideration of the motion picture engineer in order that the maximum of visual comfort may be obtained, among which may be mentioned the proper distribution of the interior illumination, the elimination of excessively bright surfaces in the field of vision, and the proper adjustment of the screen brightness. The fact that the attention of the audience must remain fixed for long periods of time upon the projected picture makes it of utmost importance that the projecting system be so adjusted that the screen brightness is neither so high as to cause visual fatigue due to glare, nor so low as to throw an undue burden upon the retinal accommodation.

The optical properties of the surface upon which the motion picture is projected determines to a great extent the ultimate efficiency of the entire installation, and hence should receive due consideration at the hands of the motion picture engineer. While there is no doubt that this is recognized, and that considerable improvement in the quality of projection screens has been made in

recent years, it seems that the subject has been approached largely from the practical standpoint and that little quantitative data are available relative to the optical characteristics of the materials used so extensively at the present time.

In view of this deficiency, it seemed worth while to examine critically the reflection properties of the large number of commercial screens on the market. From the data obtained by such exam-

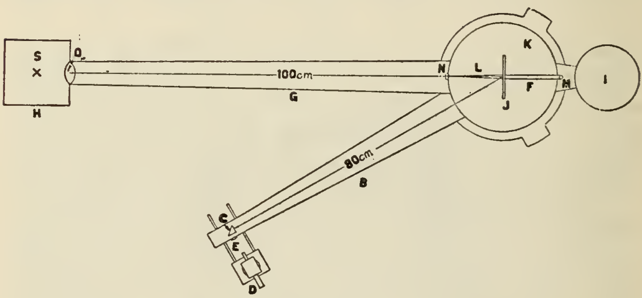


FIG. 139

ination it will be a relatively simple matter to choose the most efficient screen surface for a given installation. An examination of the commercial screens obtained showed a remarkable variation in reflection characteristics, ranging from surfaces which almost completely diffuse the incident light to screens of a very specular nature, having very high reflecting powers on the projection axis and very low values in directions departing by relatively small amounts from the normal. When the question of adapting the screen to the shape of the room in which it is to be used is considered, it will be seen that it is quite hope-

less to obtain in all cases the maximum efficiency with a screen of fixed characteristics.

For instance, if the length of the room is large relative to its width, a screen of the completely diffusing type is very wasteful of light, and the necessary screen brightness can be obtained over the required angle by the use of a screen which reflects a large proportion of the incident light within a comparatively narrow angle, thus permitting the use of lower amperage in the arc of the projection machine. On the other hand, a screen of the specular type installed in a room where the length is relatively small as compared with the width will not be found satisfactory. Since the screen in this case may be viewed by a part of the audience at a relatively large angle, it will be necessary to use a high arc current in order to make the picture of satisfactory brightness for these observers. This will result in an unnecessarily high brightness on the axis of projection and may result in excessive visual fatigue owing to glare. It should be pointed out also in case the throw is somewhat short that a highly specular screen may appear of unequal brightness when viewed from a single point of observation, since the angle of incidence varies from point to point on the screen, and that for an observer relatively near to the screen the angle of observation is not constant for all parts of the picture.

The problem of measuring and specifying the characteristics of diffusing surfaces has been treated by Dr. Nutting and results on several characteristic surfaces are given. The data given, however, relate almost entirely to miscellaneous

surfaces, only two commercial screens being included among the materials examined by him. Recently a paper by Charles W. Gamble has appeared in which he deals with the subject in a more or less general way. Here again the data given relate largely to surfaces which are not extensively used in the motion picture theatre. His results are of a qualitative character and the highest efficiency obtained is that of a mirror ground on the front surface.

Method and Apparatus

The method adopted in this investigation is quite similar to that used by other investigators and consists in measuring the brightness of the surface under examination when viewed at various angles of observation, the illumination being incident normally upon the screen surface. The incident illumination in this case was approximately parallel light, such conditions being considered as more closely approaching those existing in practice than the method used by Dr. Nutting in which case a completely diffused source subtending 1/10 of a steradian at the surface was used. In order to expedite the experimental work which involved the examination of a large number of samples, a special goniophotometer was constructed. A diagram showing the essential parts of this instrument is shown in Fig. 139.

A heavy cast-iron base *A* supports the arm *B* at the end of which is carried the photometric apparatus. In order that the observer and the photometric equipment might not interfere with the illumination of the sample at angles approaching closely to the normal, the axis of observation

was bent at right angles by use of the total reflecting prism *C*. A portable photometer of the illuminometer type was mounted at *D*, and the small lens *E* placed immediately in front of this photometer permitted the formation of an image of the surface under examination in the plane of the photometer cube. In case the texture of the surface was such as to interfere with precise photometric settings, this lens could be displaced by amounts sufficient to eliminate the disagreeable surface texture. A rigid bearing *E* supported by the base casting carries a movable arm *G* on one end of which is mounted the lamp house *H*, while at the other end a counterpoise weight *I* is placed. A holder is provided for the sample at *J*, this is so mounted that it holds the surface of the samples being examined in the plane passing through the axis of rotation of the arm *G*. The circular scale plate *K* is mounted in a fixed position relative to base *A*. A pointer attached to the sample holder indicates the angle on the divided circle. By means of a pin *M*, the sample holder can be connected rigidly with the moving arm *G*, so that the plane of the sample will remain perpendicular to the incident illumination for all positions, and as the arm *G* is rotated the angle of observation alone varies. This provides for the measurement of the surface brightness at various angles of observation and fixed direction of illumination. By removing the pin *M* and clamping the sample holder to the base *A* the arm *G* moves independently of the sample, and observations of brightness at a fixed angle of observation, but with a variable angle of incidence can be made. In the front of the lamp house is

mounted a lens O of such focal length that the source S falls at its focus. Under such conditions the light incident on the sample is approximately parallel. The dimensions of importance are as indicated in the figure. It is also so arranged that the lens O can be removed and in its place substituted a disk of diffusing material such as ground pot opal glass.

The dimensions are so adjusted that the effective area of this diffusing material is just sufficient to subtend an angle of 0.1 steradians at the surface of the sample under examination. A 500-watt Mazda C lamp of the concentrated filament type was used as a source for illuminating the samples. The voltage was precisely controlled in order to eliminate variations in brightness due to fluctuations in the line voltage. Brightness measurements were made at angles of observation from 0 to 70°. Three complete sets of readings were made by two observers on each screen, and the final result obtained by taking the average of all readings. In practically all cases excellent agreement between the individual sets of data was obtained.

The results are expressed in terms of the reflecting power of magnesium carbonate with normal illumination and observation as 100%. The absolute value of the reflecting power of magnesium carbonate is at the present time subject to some question and in view of that fact it was not deemed advisable to attempt to reduce the measurements of screen reflecting powers to absolute terms. The values given are therefore relative to that of magnesium carbonate. When a satisfactory value for this material is determined that

data can then be reduced to absolute terms, if such seems desirable.

Materials Examined

Orders for samples of the commercial projection screens were placed with practically every maker whose advertisement could be located in the trade journals. Response was not obtained from all makers, but a fairly representative group of samples was received. The standard samples were prepared by mounting a piece of the projection screen 8 inches square on a thin metal plate, thus insuring flatness of the sample under examination. In addition to the commercial screens mentioned, several miscellaneous surfaces of interest were examined.

In Table I is given a complete list of the materials measured.

The surface of the magnesium carbonate sample (1) was prepared by carefully scraping a block of the material with a steel straight-edge. The opal glass (2) was of the best quality obtainable for uniformity and whiteness, and the surface was carefully ground. The white blotting paper (3) was of the ordinary commercial quality used extensively in photographic work. The photographic stock (4) was a sample of uncalendered and uncoated material. No. 5 was of the same material but treated with the ordinary baryta coating. The drawing paper (6) was the commercial grade of Wattman's hot pressed. Sample No. 7 was prepared by sandblasting a sheet of aluminum. No. 8 was made by sandblasting the front surface of an ordinary plate glass mirror. No. 9 consists of a screen made by superposing a

sample of the material such as is commonly used as the focusing screen in photographic apparatus upon the surface of an ordinary plate glass mirror.

The commercial screens examined are also listed in Table 1, beginning with sample No. 10. In the "name" column is given the trade name applied by the manufacturer to the screen. In the "texture" column is a qualitative statement of the character of the surface, while in the "color" column is

TABLE 1

No.	Class	Name	Texture	Color
1	C	Magnesium Carbonate	Smooth	White
2	C	Opal Glass	Smooth	White
3	C	White Blotting Paper	Smooth	White
4	C	Photo Stock Plain	Smooth	White
5	C	Photo Stock Coated	Smooth	White
6	C	White Drawing Paper	Smooth	White
7	B	Sandblasted Aluminum	Smooth	Metallic White
8	A	Sandblasted Mirror	Smooth	White
9	A	Focus Screen and Mirror	Smooth	White
10	A	Superlite	Coarse Grain	Metallic White
11	A	Special	Coarse Grain	Metallic White
12	B	Green Back	Fine Grain	Metallic White
13	B	White Back	Fine Grain	Metallic White
14	C	Plain White Coated	Smooth	Yellow
15	A	Imsco Silver No. 1	Coarse Grain	Metallic White
16	A	Imsco Gold No. 1	Coarse Grain	Metallic Yellow
17	A	Imsco No. 2	Coarse Grain	Metallic White
18	A	Imsco No. 3	Medium Grain	Metallic White
19	B	Imsco No. 4	Fine Grain	Metallic White
20	C	Imsco White Muslin	Smooth	White
21	A	Minusa A	Medium Grain	Metallic White
22	A	Minusa B	Coarse Grain	Metallic White
23	A	Minusa C	Coarse Grain	Metallic White
24	A	Mazda-Lite	Fine Grain	Metallic White
25	B	Idealite-Grade 1A	Fine Grain	Metallic White
26	B	Idealite-Grade 1B	Medium Grain	Metallic White
27	B	Idealite-Grade 2	Fine Grain	Metallic White
28	C	Dalite Crystal White	Smooth	Blue Green
29	B	Dalite Gold Fibre	Fine Grain	Metallic Yellow
30	A	Dalite Silver	Fine Grain	Metallic White
31	A	Argus Crystal Bead No. 1	Medium Glass Beads	Yellow
32	B	Argus Crystal Bead No. 2	Fine Glass Beads	Yellow
33	B	Mirroroid	Fine Grain	Metallic White
34	A	Gold Ring	Smooth	Metallic Yellow
35	C	Half-tone	Smooth	White
36	A	Aluminum Paper	Smooth	Metallic White

a qualitative statement of the color. The terms used in specifying texture and color are very general in nature, no precise quantitative measurements being made of these characteristics. An examination of the characteristics of these screens shows that they can be roughly grouped into three general classes which may be specified as follows: Included in Class C are those screens which give almost complete diffusion of the incident light. Class A includes those which reflect a large proportion of the incident light within a

MISCELLANEOUS SURFACES

No.	ANGLE									
	0	5	10	15	20	30	40	50	60	70
1	100	100	99 9	98 0	96.9	94.9	92.4	89 5	84.8	78.8
2	77.1	77.1	76.0	76 0	74.8	73.7	73.7	72.6	70.5	68.2
3	68.9	67 9	65.9	64 0	63 0	60.8	59 7	57.2	54.8	54.2
4	73.9	73.9	71.2	70 0	67 0	65.0	63 5	62 2	61.1	58.4
5	91.1	88.0	84.9	82.5	80 5	79.3	78.7	78.7	76.9	74.3
6	82.7	82.7	81.5	77.8	74.4	72.0	69.5	63.3	67.6	65.4
7	66.3	64.1	61 4	57 6	52.4	46.5	40.1	36.0	35.3	32.6
8	473	399	297	224	121	62.0	40.2	34.2	32.0	31.1
9	460	430	373	257	176	73 3	31.9	20.5	19.0	[illegible]9.4

very narrow angle, and very little light at the greater angles. Class B includes the screens which are intermediate between the extremes represented by Classes A and B. It should be understood that the line of demarkation between these three classes is not distinct but that such classification is entirely arbitrary and made only for the purpose of practical convenience. The names specular, semi-diffuse, and diffuse may conveniently be applied in the classes A, B, and C, respectively. The indication of the class to which each screen belongs is given by the letter in the "Class" column of Table 1.

Results

In Table 2 are given the reflecting powers at the various angles of the miscellaneous surfaces examined, while in Table 3 are the detailed data relative to the reflection characteristics of the twenty-seven commercial screens examined. In order to present these data in more graphic form they are plotted as curves in the following figures,

TABLE 3

COMMERCIAL SCREENS

10	268	256	215	168	120	64.8	34.3	21.8	16.8	14.2
11	300	284	255	206	167	93.9	52.2	26.5	17.0	13.3
12	208	203	188	161	134	85.0	53.3	33.0	22.4	18.3
13	177	174	165	143	122	85.9	53.0	33.0	23.8	17.7
14	72.9	72.2	70.8	70.5	69.4	68.9	68.1	68.8	67.0	64.0
15	286	273	229	173	129	66.0	33.0	21.4	15.2	13.7
16	311	288	234	180	125	66.0	35.0	21.7	15.6	14.0
17	230	220	200	171	141	83.1	47.4	29.6	20.3	16.0
18	208	197	177	152	127	80.6	47.9	34.3	24.3	19.9
19	186	183	169	146	120	79.8	47.9	31.3	22.2	17.6
20	66.4	66.3	65.2	63.6	62.4	61.0	60.4	60.0	59.3	58.9
21	326	308	270	204	157	76.0	38.6	25.7	15.0	12.6
22	355	339	274	207	149	71.7	35.8	21.7	15.0	12.8
23	315	298	256	203	151	77.9	38.9	23.0	16.1	13.0
24	334	323	276	215	160	82.9	40.0	24.5	16.6	13.8
25	154	151	136	112	97.0	75.1	56.0	52.9	47.0	43.0
26	193	187	154	124	98.5	72.2	58.4	50.2	45.2	40.9
27	142	137	122	103	93.6	76.4	63.7	55.6	50.8	46.8
28	71.7	71.7	70.8	69.9	69.2	68.6	67.1	66.0	65.3	64.8
29	126	120	116	104	90.7	68.8	47.1	34.3	26.5	21.9
30	183	172	157	134	107	65.0	42.1	28.8	20.9	16.8
31	244	240	177	116	75.6	45.5	40.0	39.6	41.7	43.7
32	140	138	113	91.4	78.6	60.9	54.8	50.8	50.4	50.0
33	142	138	129	109	99.0	73.4	49.5	35.7	27.4	22.5
34	292	271	216	160	108	49.2	28.4	17.4	13.1	9.7
35	78.6	78.6	74.9	73.3	71.1	68.6	65.3	63.9	62.3	59.5
36	148	136	111	93.6	74.1	50.2	34.1	26.5	22.6	19.5

the ordinates in all cases being values of relative reflecting powers and the abscissae the angles of observation to which the various reflecting powers apply.

In order to facilitate the examination of the data, it will be well to separate them into their respective classes. After careful consideration of the characteristics of the screens and of the requirements of practical use, it was decided to

define the range covered by these classes as follows:

Class A includes those screens which are adapted for use in theatres where the maximum angle of observation does not exceed 30°; Class B includes the screens adapted for use where the maximum angle of observation does not exceed 50°, while the Class C screens should be used in

TABLE 4

CLASS A

No.	20°		30°		40°		50°	
	$\frac{R_o}{R_{20}}$	R_a	$\frac{R_o}{R_{30}}$	R_a	$\frac{R_o}{R_{40}}$	R_a	$\frac{R_o}{R_{50}}$	R_a
8	3.91	305	7.62	235	11.8	194	13.8	165
9	2.61	339	6.30	270	14.4	217	22.4	183
34	2.70	209	5.94	167	10.3	137	16.8	116
31	3.22	159	5.48	127	6.10	108	6.17	96
22	2.38	265	4.96	216	9.92	167	16.3	151
15	2.21	218	4.34	178	8.70	147	13.4	134
21	2.06	253	4.30	207	8.47	172	13.2	145
10	2.23	205	4.14	169	7.82	140	12.3	119
24	2.08	253	4.02	209	8.35	174	13.6	147
23	2.08	245	4.00	201	8.10	167	13.7	141
1[illegible]	1.80	242	3.20	204	5.75	172	11.3	147
16	1.69	228	3.20	184	6.03	152	9.75	130
36	2.00	112	2.96	96.4	4.34	83.3	5.59	73.2
30	1.70	151	2.82	128	4.35	110	6.36	87
17	1.63	192	2.77	165	4.85	141	7.77	121
18	1.64	172	2.58	150	4.25	128	6.07	112

all cases where the angle of observation is greater than 50°. The point should be again emphasized that these classifications are not rigid, but of an approximate character.

After careful consideration of the subject, it was decided that the value of the ratio of the reflecting power measured at normal observation to that measured at the maximum angle of observation in a particular installation would serve as

the most logical criterion by which to select the most suitable screen for that particular case.

This value will then represent the ratio of the brightness of the screen as observed by a person in the center of the auditorium to that of the brightness as observed by a person occupying a seat at the side and near the front. By keeping this ratio below a certain limiting value, satisfactory brightness will be obtained for all observers. This factor alone, however, is not sufficient for the classifying of screens according to their relative merits. The highest average reflecting power within the required angle from the normal will necessitate the least energy expenditure in the projecting system to produce a given screen brightness.

Assuming cases in which the maximum angles of observation are 20°, 30°, 40°, and 50°, the values of the ratio of the reflecting power at normal observation to that at these various angles were computed for all screens and likewise values of mean reflecting power for the same limiting angles. These values are tabulated for the Class

TABLE 5

CLASS B

No.	20°		30°		40°		50°	
	$\frac{R_0}{R_{20}}$	R_a	$\frac{R_0}{R_{30}}$	R_a	$\frac{R_0}{R_{40}}$	R_a	$\frac{R_0}{R_{50}}$	R_a
12	1.55	179	2.45	155	3.91	135	6.30	117
19	1 55	161	2 34	141	3 88	129	5.95	109
13	1.45	156	2.06	139	3.34	121	5.37	106
33	1.43	123	1.93	111	2.87	99	3.97	88
26	1.96	151	2 67	131	3.30	115	3.70	104
29	1 39	111	1 83	100	2.68	90	3.68	79
25	1.59	130	2 05	115	2.75	104	2.91	94
32	1.78	112	2.30	99	2.56	89	2.76	82
27	1.52	120	1 86	108	2.23	98	2.56	91
7	1.26	60 3	1.42	56 7	1.65	53.5	1.84	50.4

TABLE 6

CLASS C

No.	20°		30°		40°		50°	
	$\frac{R_o}{R_{20}}$	R_{m20}	$\frac{R_o}{R_{30}}$	R_{m30}	$\frac{R_o}{R_{40}}$	R_{m40}	$\frac{R_o}{R_{50}}$	R_{m50}
6	1.10	79.8	1.15	77.7	1.19	76.1	1.30	74.6
35	1.10	75.3	1.14	73.5	1.20	71.7	1.23	70.4
3	1.09	65.8	1.13	64.6	1.15	63.5	1.20	62.5
4	1.10	71.2	1.13	69.6	1 16	68.3	1.19	67.3
5	1.13	85.4	1.15	83 5	1.15	82 7	1.15	82.0
1	1.03	99.[illegible]	1.05	97.9	1.08	96.8	1.12	95.5
14	1.05	71.0	1.06	71.0	1.07	70.0	1.07	67.0
20	1.06	64.0	1.09	64.0	1.10	52.0	1.10	54.0
28	1.02	71.0	1.03	70.0	1.04	70.0	1.07	69.0
2	1.03	77 1	1.05	76.2	1.05	75.6	1.06	75.0

A screens in Table 4, those for the Class B screens in Table 5, and those for the Class C screens in Table 6.

Now it seems reasonable to demand that the ratio of the brightness on the axis to that at the extreme angle of observation shall not be greater than 4.0. This value is decided upon after consideration not only of the variation in brightness as observed from various points in the auditorium, but also from a consideration of the fact that from a given point of observation the screen may appear of unequal brightness over its area. The danger of this inequality being serious increases rapidly as the value of the above mentioned ratio in reflecting powers increases. A detailed consideration of the geometry of this problem might make this point more clear, but it is not desired to lengthen this paper to such an extent as to include a complete treatment of the subject. Assuming now that we adopt the value of 4 as the limiting value of the reflecting power ratio, it is possible from the figures in Tables 4

to 6 inclusive to choose the best screen for any one of the cases considered. For instance, assuming that the maximum angle of observation is 20°, it will be noted that all values in the ratio column are less than 4. Therefore from the standpoint of distribution any one of the screens in Class A will be satisfactory for use where the angle of observation does not exceed 20°. In order now to obtain the maximum average brightness within this angle for a minimum current consumption it is only necessary to choose that screen, or screens, which show the highest value in the column marked R a. Now assuming a maximum angle of 30° we find that the first seven screens are excluded since the ratio of normal to extreme reflecting power is greater than 4. Beginning with No. 11 we may then choose the screens showing the highest average reflecting power for the range 0 to 30°. When the maximum angle of 40° is considered we find no screen in Class A which does not exceed the limiting value of 4 for reflecting power ratio. We therefore turn to Table 5, and there find that all values of the reflecting power ratio are less than 4. We may therefore select from Class B that screen which has the highest reflecting power for the 0-40° range. In case of the 50° limiting angle, three of the Class B screens are automatically excluded, and it is only necessary to select from the remainder the one having the highest average reflecting power for the 0-50° angle.

It should be emphasized that this method of selecting a projection screen recognizes only the reflection characteristics of the screen and further that these are considered only from the standpoint

of intensity. In many cases it will be found that several screens are practically of equal value when judged by this criterion. In such cases other considerations such as color, surface texture, durability, and other physical properties may be the deciding factors in the final choice. Many of the screens examined show excellent characteristics and while the screen makers are to be congratulated on many of these screens, it is to be hoped that this critical examination of screen characteristics may stimulate them to greater efforts and to the production of even better and more efficient surfaces for this purpose.

METHOD AND APPARATUS FOR PROJECTING MOTION PICTURES WITH COLOR EFFECTS

David Wark Griffith has received from the Commissioner of Patents at Washington the exclusive right to "make, use and vend certain methods and apparatus for the projection of motion and other pictures with color effects."

The Griffith patent, granting protection for a term of seventeen years, was secured by Albert L. Grey, Mr. Griffith's general manager, through Attorney O. Ellery Edwards, and will give the producer ample protection against the copying or appropriating of his lighting effects in color, first introduced by Mr. Griffith in connection with the showing of "Broken Blossoms" at the George M. Cohan Theatre, New York City.

The Griffith patent covers a wide range of lighting, including the process and apparatus by means of which either moving or other pictures may be projected onto an illuminated screen which has colored lights blending with the pictures shown. These and other inventions are covered by the patent, the embodiment of which are as follows:

"The process of producing colored pictures on an opaque screen, which consists of throwing pictures by a projector onto one surface of said screen and simultaneously illuminating the screen with diffused colored lights thrown onto the same surface of the screen in a direction oblique to the stream of light from the projector.

D. W. GRIFFITH.

METHOD AND APPARATUS FOR PROJECTING MOVING AND OTHER PICTURES WITH COLOR EFFECTS.

APPLICATION FILED MAY 14, 1919.

1,334,853. Patented Mar. 23, 1920.

2 SHEETS—SHEET 1.

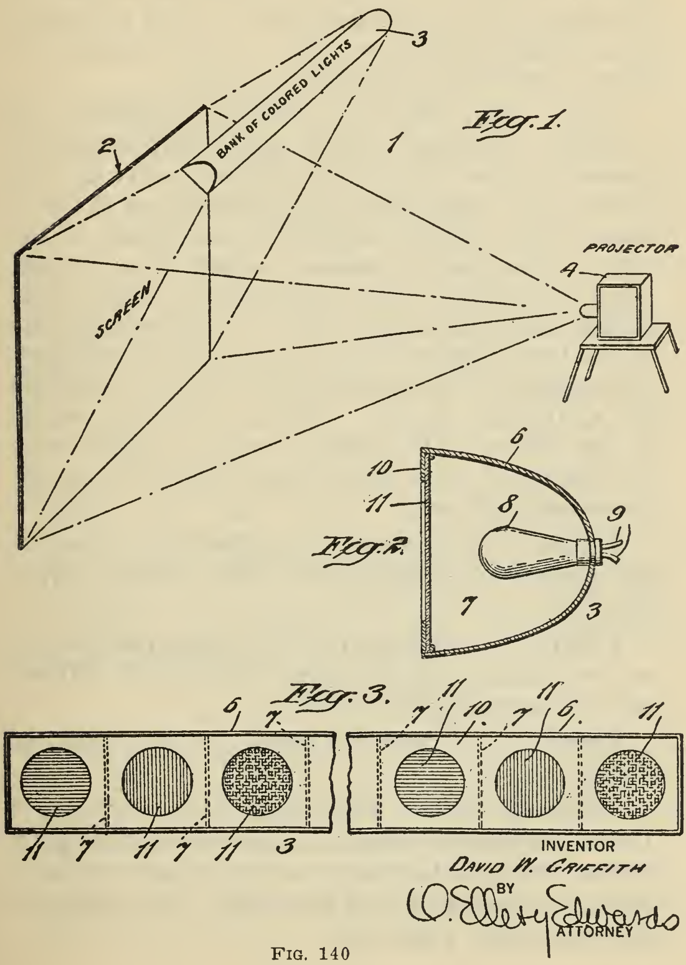


FIG. 140

"In an apparatus of the class described, the following equipment. An opaque screen, a projector, a bank of colored lights out of the path of light from said projector and for the purpose of throwing diffused colored light onto the same surface of said screen, so that a colored picture is shown when the apparatus is in use."

Those who saw Mr. Griffith's production of "Broken Blossoms" during the Griffith repertory season in New York will recall the illusive curious tinted lights that came and went across the surface of the picture during the unfolding of the story. The scenes seemed bathed in a vibrant mauve, while the inner core of the picture itself shimmered with salmon pink. The symbolic blue of the Orient lighted the Chinese scenes, and gave atmosphere to the portions of the story wherein the Chinaman figured. Words cannot do justice to the photographic effects, many of which were like beautiful moving canvasses colored by an impressionistic touch.

Figure 1—A perspective diagrammatic view of the preferred embodiment of the Griffith invention.

Figure 2—A sectional view through the bank of colored lights for throwing direct and diffused colored lights on the screen.

Figure 3—A front elevation of this bank of light.

Figure 2—When the trough (6) is bent, it forms a suitable reflector, and has suitable glow lamps (8) mounted therein, one in each compartment, and supplied with electricity from any suitable source by wires (9).

Figure 3—A long trough (6) has a number of partitions (7) which divide the space in the trough into several distinct compartments, so ar-

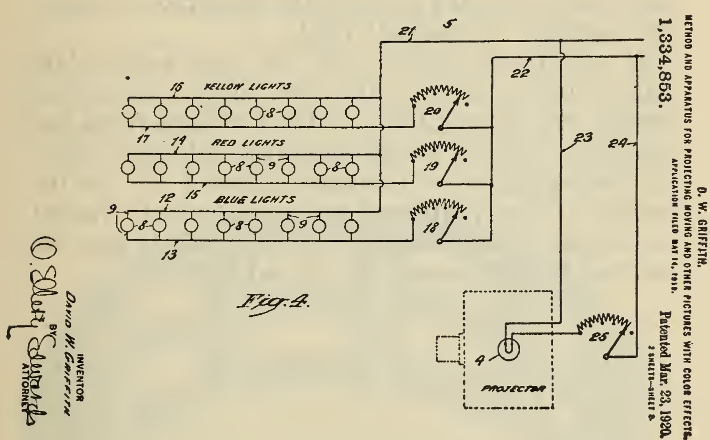


FIG. 141

ranged that light cannot leak from one to another. The front of the trough is closed by a perforated plate (10) and each perforation is closed by means of a colored diaphragm or screen (11).

Figure 4—A diagram of the wires and lights used with the Griffith invention.

DESCRIPTION

The glow lights (8) have their wires (9) run to the ordinary main wires, which are designated 12 and 13 for the blue lights, 14 and 15 for the red lights, and 16 and 17 for the yellow lights.

The blue lights are controlled by a rheostat or dimmer (18), the red lights by a corresponding instrument (19) and the yellow lights by another

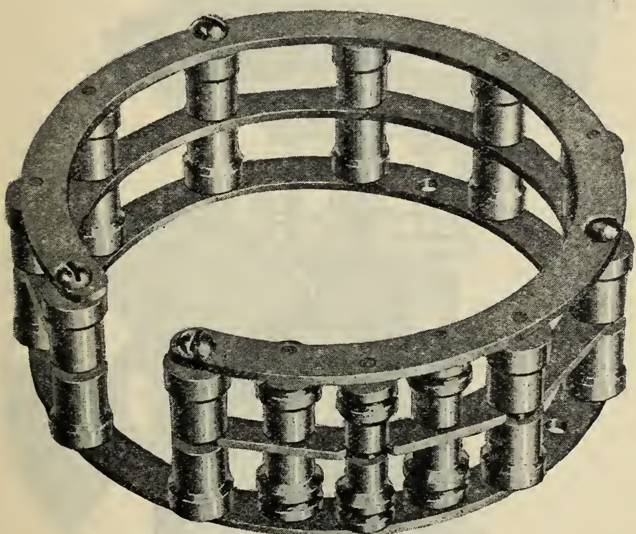
(20). The wires (12, 14, 16) run to the bus bar (21) and the rheostat (18, 19, 20) are connected to the other bus bar (22). Wires 23 and 24 connect these bus bars through the projector (4) and its regulator or rheostat (25).

If electricity be shut off the red and yellow lights, and turned on the blue lights, the entire screen will appear blue, and the images from the projector will be correspondingly colored. Also, by the regulators or dimmers (18 and 25) the intensity of illumination of the screen may be varied so that an infinite number of color effects may be produced with one set of colored lights.

FEASTER IMPROVED NO-REWIND

Important improvements have lately been made on the Feaster No-rewind machine. Here is a device that saves the operator's time—lessens the fire risk—lengthens the life of the film and helps to keep a perfect projected picture on the screen.

As will be seen by referring to the photograph,



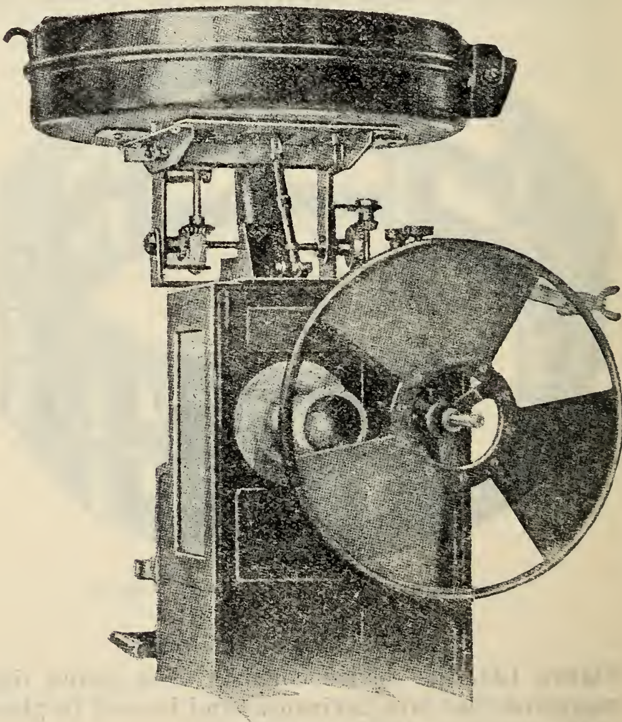
Ball Bearing Rollers to Eliminate Friction

FIG. 142

Figure 143, the device consists of a round film magazine that lays horizontal and is used in place of the upper vertical magazine.

Within the magazine is a ball bearing pan on

which the film is placed and on which the film rotates. When threading the projector the film is started from the center instead of from the outside. It is first threaded through the feed sprocket within the magazine and then through the projector in the usual fashion. A special reel is used in the take-up magazine on which the film is wound. The reel is so constructed that by releas-



Feaster No-Rewind

FIG. 143

ing a friction catch one of the sides of the reel can be removed, thus allowing the film to be laid onto the rotating pan in the upper magazine (no reel is used in the upper magazine). As the film feeds from the center it is not necessary to rewind after showing.

The device can be attached to any make of projection machine in a few minutes without making any mechanical change except the removal of the old style upper magazine. Once the film is threaded through the projector it needs no further attention.

Both the Feaster machine and the reels are well constructed and with ordinary wear and tear should outlast the life of the projecting machine.

The drawback to the machine in the past has been that it was made to take one thousand feet of film only. This I am given to understand has now been overcome by the Feaster people having had a larger magazine, capable of taking at least two thousand feet of film. I would suggest your getting in touch with the Feaster people for fuller particulars regarding this worthy addition to the up-to-date projection room.

AUTOMATIC ARC CONTROLS

Arc controls may be listed in three classes: Double motored, single motored, and mechanical.

Double Motored

This type consists of two similar motors connected through differential gearing, the central gear of the train being connected to the arc feed handle. One of the motors is connected across the line and the other across the arc terminals. The proper carbon setting is selected and the speeds of the two motors made identical by a rheostat in series with the one placed across the line. Once this adjustment has been made there will be no movement of the carbons as long as the voltage across the arc gap remains unchanged. When this voltage does change, the speed ratio of the differential will cause a movement of the arc feed shaft and the arc gap will be altered either one way or the other until normal conditions have been restored.

The double motored type makes it possible to have the striking of the arc carried out automatically, without attention on the part of the projectionist beyond the throwing of the switch.

Single Motored

In the case of the Peerless, the device consists of a make and break mechanism connected across the arc terminals which, in turn, starts and stops the motor driving the arc feed shaft.

Still another single motor controller is the Speedco. The motor used with this controller is

shunt-wound, the fields being connected across the incoming line while the armature is connected across the arc terminals. A centrifugal clutch between the motor and the feed mechanism allows the motor to run free until such time as the arc voltage becomes too high. When the arc voltage rises to too high a value, the centrifugal clutch operates, thereby allowing the motor to drive the arc feed mechanism directly. As soon as the arc has been shortened enough to reduce the arc voltage to the proper value, the motor speed, having decreased, the centrifugal clutch disengages and no further feeding takes place.

The Mechanical Type

The action of the mechanical type of arc controller differs from that of the other makes by the fact that its operation is in nowise affected or controlled by the variations in current or voltage at the arc. The mechanical control is usually connected to the projector motor in some way so that whenever the motor is in operation, the carbons are fed together at a continuous rate by means of a flexible shaft extending from the motor attachment to the arc feed handle. Once adjusted this device will continue to operate at the same rate as long as the motor turns. The Tepico arc feed is of this type.

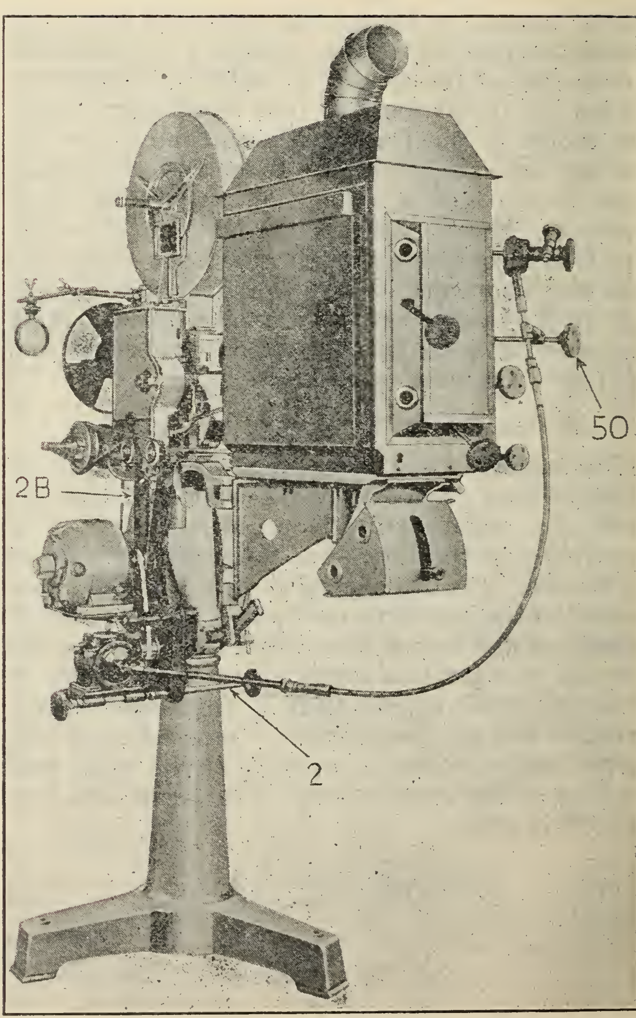


FIG. 144

THE SIMPLEX AUTOMATIC ARC CONTROL

The Simplex Arc Control is of the mechanical type. Two conical pulleys, 7-8 Fig. 148, are driven by a wide flat belt which in turn is driven by a pulley on the motor shaft, while two idler pulleys, 11 Fig. 145, 10 Fig. 148, keep this driving belt permanently in alignment with the motor pulley. As long as the driving belt is held in the dead center of both conical pulleys the shafts, etc., which operate the arc lamp adjustments will be held stationary, but as will be seen by the photograph Fig. 145 should the driving belt engage the pulleys at any point other than the dead center, one of the pulleys will be run faster than the other (due to their conical shape). It is this difference in speed which actuates the shafts that either feed the carbons or lengthen the arc.

Should the conical pulley 7 Fig. 148 be driven faster than its mate 8 Fig. 148, then the feed shaft will be rotated so that the carbons will be moved apart, thus lengthening the arc, while if pulley 8 Fig. 148 is driven faster than pulley 7 Fig. 148, the shaft will be actuated so that the carbons are fed.

Provision is made by means of a regulating handle, 54A Fig. 145 (which can be operated from either side of the projector, see Fig. 148), to allow the operator to alter the belt position on the conical pulleys so that he can regulate the speed at which the carbons will be fed.

Provision is also made to allow the operator to adjust the arc by hand without in any way

interfering with the control attachments or altering any of the control adjustments. This is accomplished by means of a friction disk, 53 Fig. 147.

As this is a product of the Precision Machine Company a mechanically perfect well-built piece of mechanism is assured.

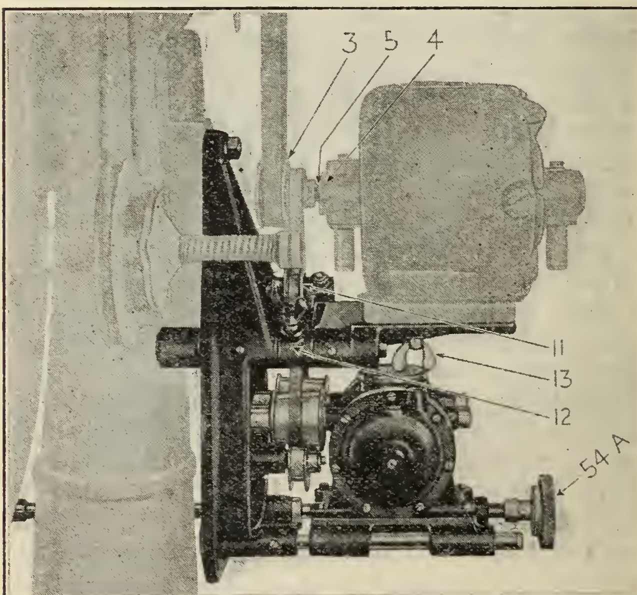


FIG. 145

INSTRUCTIONS FOR SETTING THE ARC CONTROL MECHANISM ON THE "S" LAMP

Detach the standard motor table and attach in its place the main frame (1) of the arc control mechanism, by clamping the fastening bolt (1-A).

CAUTIONS

(a) See that dowel pin in back of main frame engages slot in pedestal column.

(b) See that adjusting screw (2) does not touch the projector column; the clearance should be about 3/16 in.

(c) As in setting the old motor table, the position of the arc control frame will depend on the tension of the driving belt (2-B). The entire mechanism can be shifted vertically without interfering with its operation.

Before setting the projector motor on the upper platform of the arc control structure, fasten to the motor shaft the double pulley (3).

CAUTIONS

(a) See that the small pulley is set toward the motor.

(b) See that the clearance between the hub of the pulley (3) and the hub of the motor bearing (4) is about ⅛ in.

After the double pulley (3) is fastened to the motor shaft (5) throw the arc control belt (6) across the two cone pulleys (7-8) on the differential case (9) and by tilting the motor toward the projector, let the belt engage the small pulley on the motor shaft. See that the belt engages the locating pulley (10) and the tension pulley (11) on the tension lever (12).

CAUTION

If the motor is not properly aligned with the pulleys (7-8-10-11) of the arc control mechanism, the tension and locating pulleys (10-11) will create a loud rattling noise. To bring the motor to proper adjustment:—

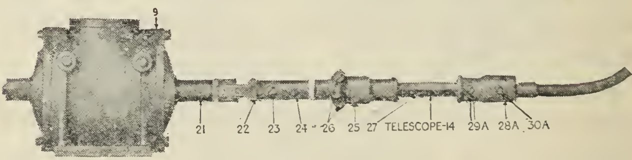


Fig. 146

(a) Unfasten wing screws (13) securing motor to table.

(b) Start the motor running.

(c) Adjust motor (while running) laterally toward or away from projector frame until tension and locating pulleys (10-11) are silent.

Set the projector belt on the outer end of the new motor pulley (3) and lower or raise the arc control frame till the proper tension is obtained.

HOW TO CONNECT THE CENTRAL SHAFT OF THE DIFFERENTIAL CASE (9) TO THE CARBON FEED CONTROLLING HANDLE OF THE ARC LAMP MECHANISM

The transmission gear consists of:—

A telescope	14	Handle Gear
A flexible shaft	15	
A rigid extension	16	
A reducing gear	17	
A spring chuck	18	
A handle shaft	19	
A swivel joint	20	

Attached to the central shaft of the differential case (9) there is a universal joint (21). With the screw (23) secure the male end (22) of the joint to the tube (24) of the telescope.

The telescope consists of the tube (24); the square chuck (25); the square shaft (27); and the coupling (28-A).

See that the screws (26) on the square chuck (25) are screwed in to their limit. They fasten the square chuck (25) to the tube (24) of the telescope.

Detach the standard carbon adjusting handle and coupling of the "S" lamp, by withdrawing the cotter pin (43) and pin (42) on the coupling (41).

Detach handle flange (50) on the "S" lamp and slide part (34) of swivel joint onto handle rod (51). Replace handle flange (50).

Attach the arc control handle gear to the gear shaft (40) by means of the universal joint (38) and screw (39).

Insert ends of flexible shaft (15) in chucks (28-A and 28-B) and secure them by means of screws (30-A and 30-B).

Start the electric motor running.

The handle (53) and shaft (19) will slowly rotate toward the left and set the carbon jaws in motion, one toward the other.

If the handle (53) does not rotate and you have made sure that all the fastening screws (23-26-29A-29B-30A-30B-37-39) have been thoroughly tightened, then it must be that the tension at the

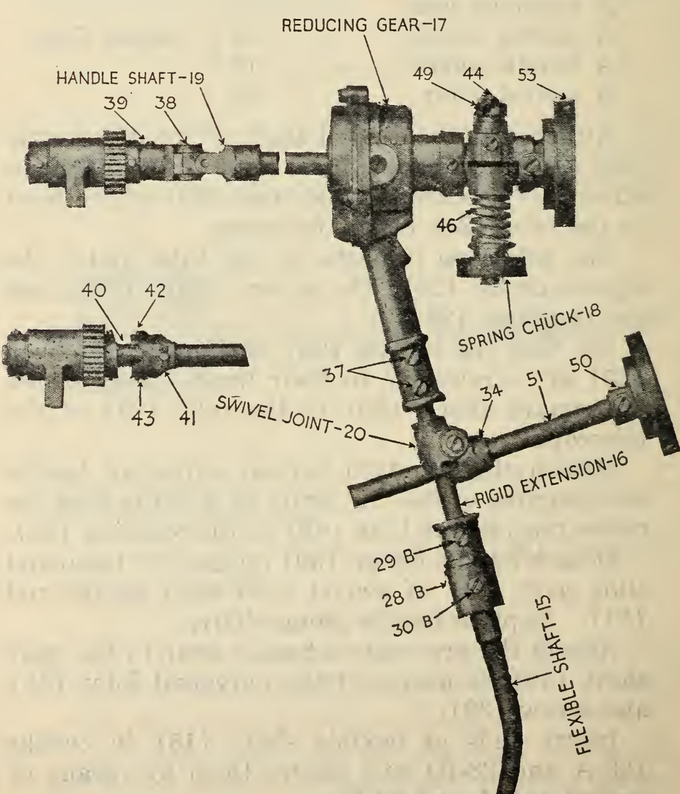


FIG. 147

spring chuck (18) is not sufficient to overcome the resistance of the lamp.

The spring (46) of the spring chuck (18) is set in our testing room for the average resistance of the "S" lamp.

To increase the tension at the spring chuck (18) :—

(a) Loosen nut 49.

(b) With screw driver, turn stud 44 toward the right (from knob end) till handle 53 starts to rotate.

(c) Fasten nut 49.

HOW TO STRIKE THE ARC AND SET THE ARC CONTROL

Strike the arc as usual by revolving handle (53) toward the left and set the proper arc length by hand.

Watch the arc for about one minute, then :—

(a) If the arc length *increases* revolve the adjusting handle (54-A) about one revolution at a time, toward the right till the proper gap between the carbons is maintained.

Note—The foregoing operation is based on turning handle 54-A on operating side of machine. When using handle on motor side turn toward the left.

(b) If the arc length *decreases,* adjust similarly the handle (54-A) toward the left.

Under normal conditions this initial adjustment will last indefinitely.

If the amperage at the arc is changed, the feed will vary correspondingly and new adjustment will be required.

Using the same motor which operates the picture machine and incorporating the most ingenious and ruggedly constructed differential, the Simplex arc feed can well be called an extreme departure

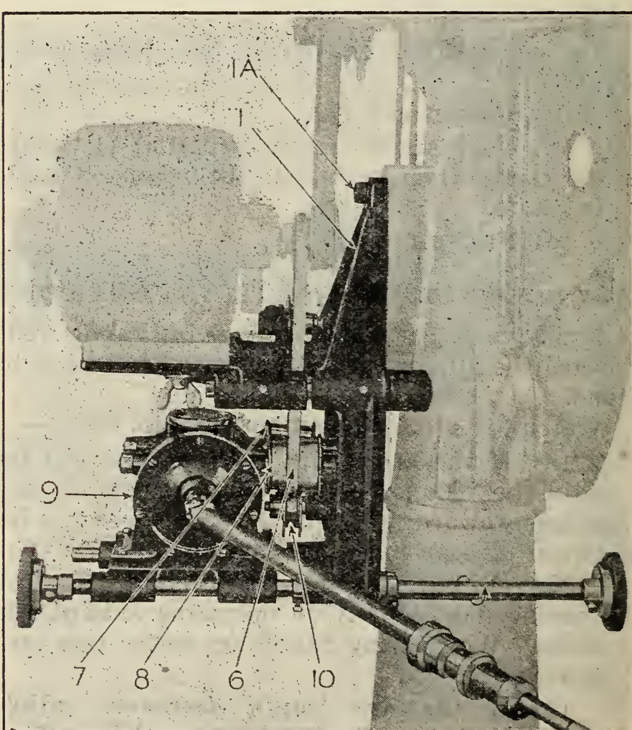


FIG. 148

from anything now on the market. Its design does not include the use of added motors, governors, relays, springs, solenoids, magnets, clock works, or friction discs, and yet it works efficiently under

any or all conditions (A. C. or D. C.) in a manner that is quite unbelievable. Cold carbons, line fluctuations or extreme abnormal electrical conditions in no way hamper the performance of this most wonderful little device which has been for several years in the making by the engineers and builders of the famous Simplex Projectors.

The Simplex arc-control is mounted upon the present motor table location, which carries it away from the dust and fine particles of asbestos and cement that are constantly being worn off the floor of the projection room by the shuffling of feet. This location not only prevents many of these particles from being ground into the bearings and shafts, but permits also ease of operation due to the convenience of its within-easy-reach position.

Its installation requires but the substitution of the different type of motor table, upon which is mounted the differential unit, and this unit with the machine motor, together with the flexible feeding rod and most ingenious feeding handle comprises the entire equipment. The feeding handle unlike many that are now in use, can be instantly used without detaching or loosening of any sort, either as a hand feed or motor feed, containing as it does a simple enclosed gripping device that is at all times positive without any wearing parts, springs, clutches or pawls.

THE PEERLESS CONTROL

The Peerless Control is made for use on all makes of projectors having Direct Current at the arc, and will operate equally well with current supplied by a Motor Generator, Converter, Mercury Arc Rectifier or 110 volt D.C. from the power companies.

The instrument is designed to stand on the floor at the rear of the projector, the power being transmitted from the motor mounted on the Control to the feed handle of the arc lamp by means of a telescoping tube and shaft that automatically adjusts itself for the various height projectors.

A complete feed handle assembly shown in the accompanying line drawing, consisting of the parts M, J, N, F, P with a worm gear and worm mounted thereon is supplied as a part of the *Peerless* Control, and replacing the regular feed rod and handle on the projector.

The actuating element is completely enclosed and the entire device is approved by the Underwriters Laboratories Inc., their approval number E-4988.

The operation of the Control is governed by changes in the arc voltage there being two highly sensitive magnets in series with each other connected directly across the line in multiple with the arc and their strength varies directly proportionate to the variation in the arc voltage. These magnets influence an armature carrying contact points having a gap of approximately ".006," and

to the armature is connected a spring which in turn is attached to the adjusting screw marked "A" on the accompanying line cut. The various length arcs may be obtained by screwing in or out this adjusting screw.

These contacts open and close a circuit to the special wound series type motor. It will be readily seen that when the attraction of the magnet exceeds the opposite pull on the spring attached at the end of the screw "A" that the armature will move toward the magnet and the circuit close with the result that the motor rotates and feeds the carbons together until the arc voltage has decreased and in turn the magnetic strength of the magnets decreased to a point where the spring is the stronger, with the result that the circuit is opened.

Due to the type of construction employed in the manufacture of this element, a degree of sensitiveness of less than 1/5 of one volt is obtained, that is to say, that an increase in the arc voltage of less than 1/5 of one volt above the point for which the adjustment is set will close the circuit. Thus securing a delicacy and fineness of operation that is truly remarkable.

A gear reduction through two sets of worm gears one on the Control itself and the other on the feed handle provides a gear ratio of 6400 to one, with the result that the movement of the carbons can scarcely be detected with the naked eye, and insures against any disturbances on the arc crater, as would be the case where they moved rapidly such as is so often the practice with the hand-fed arc.

A high resistance unit is connected in series with the motor, permitting some current to enter the motor at all times when the knife switch of the projector is closed. This resistance serves the

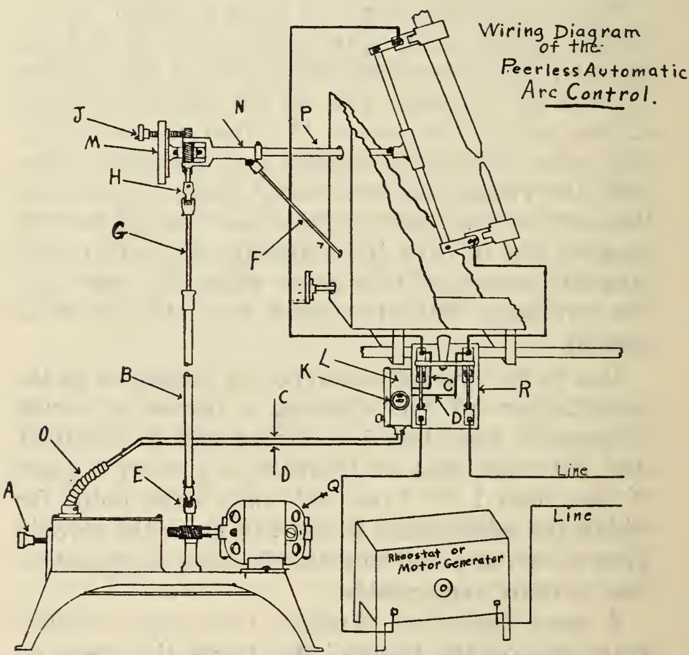


FIG. 149

purpose of reducing to a minimum the load which the circuit breaker has to break and acts as a discharge coil as well, thus eliminating any destructive spark.

The automatic arc controls have been on the market long enough to have their general merit

well proven and taken altogether are highly recommended for use in theatres desiring high grade screen results.

INSTRUCTIONS FOR INSTALLING AND OPERATING THE PEERLESS AUTOMATIC ARC FEED

This control is made for use on projectors using *Direct Current* at the arc only.

Carefully unpack the control from the box containing it, and remove all parts. Place the instruments on the floor directly beneath the arc feed handle. Attach the nickel-plated tube (shown as "B" on the blue print) to the gear shaft universal joint by means of the screw and nut furnished, and insert the shaft "G" into the tube.

If the arc control is to be used on a Powers, Motiograph or Type "S" Simplex arc lamp, remove the arc feed handle and rod and replace with the complete assembly furnished with the control same as it is received.

If the control is to be used with the "regular" type Simplex arc lamp, having the feed rod rigidly attached to the arc lamp, it is only necessary to remove the Simplex fibre handle and in its place assemble the parts shown as "N", "J", "M" and the gears, collars, etc. onto the Simplex rod.

Drill a small hole in the rear of the lamp house, about five inches below the opening for the arc feed rod and insert the anchor "F", or attach anchor to one of the adjusting rods by means of clips furnished.

Attach the universal joint at the end of the rod "G" to the shaft "H" on the feed handle.

The control is then ready for the electrical connections. Bear in mind that the *Peerless* control is a voltage-governed device and is actuated by changes in voltage at the arc, caused by the increase in the arc gap due to the consuming of the carbons. It is necessary, therefore, that the device be connected in multiple with the arc, and at a place in the lamp circuit where it will receive current *after* it has passed through the rheostat or motor-generator, as shown on the blue print.

Attach a snap switch and a fuse block, shown as "K" and "L" on the print, at a convenient place at the rear of the projector, a good place being at the side of the arc lamp knife switch box, as illustrated. Encase the wires "C" and "D" in flexible Greenfield conduit "O" and run to the switch and make connections. From the switch "K" run wires to inside of knife switch "R" cabinet and connect to each of the arc feed wires as shown, being sure that the current which will enter the control at this point, has already passed through the rheostat or motor-generator.

See that the snap switch "K" is "off" and strike the arc and allow it to burn until the crater has properly formed on the carbons. Bring the carbons together to the arc gap which you wish maintained, turn on the switch and loosen knurled clamping screw "J" on the feed handle. If the motor runs when the carbons are at the gap desired, slowly screw out the arc gap adjusting screw "A" until the motor stops. Any arc gap desired may then be obtained by screwing in or

out the screw "A"—in, to shorten the gap and out, to lengthen it. The control will automatically maintain the arc gap for which screw "A" is set, and further adjustment of it is not needed and its position should not be changed.

When putting a new trim of carbons in the lamp, allow them to burn in before turning on the snap switch "K", as the voltage at the arc is much lower than normally until craters have formed, which would result in the control failing to feed until the craters had formed and the voltage raised to normal at the desired gap.

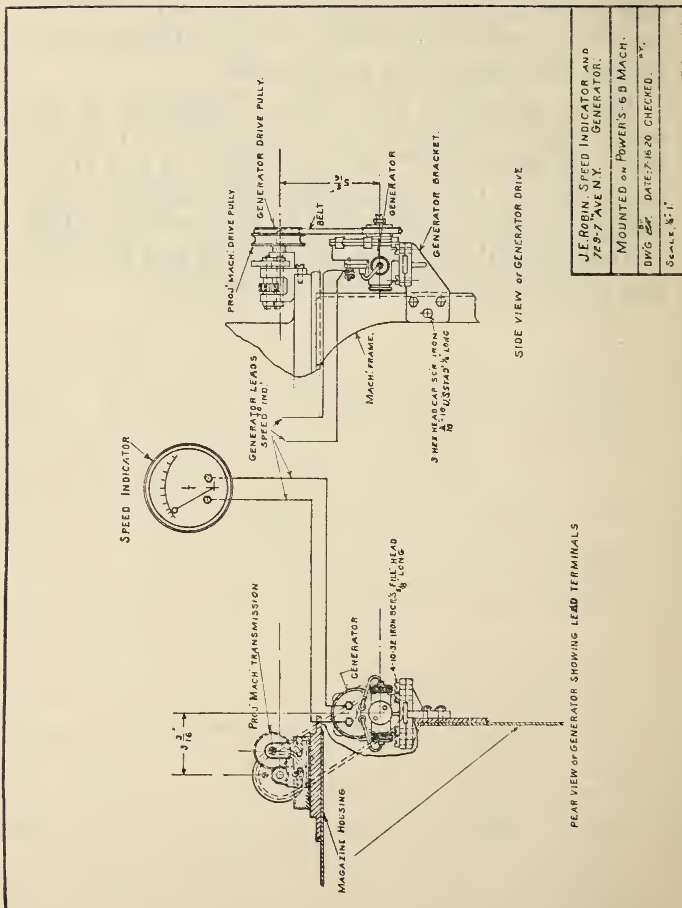

J.E. ROBIN. SPEED INDICATOR AND GENERATOR.
729-7th AVE N.Y.
MOUNTED ON POWER'S 6B MACH.
DATE: 7-16-20 CHECKED BY.
PROJ' MACH' DRIVE PULLY
GENERATOR DRIVE PULLY.
BELT
GENERATOR
GENERATOR BRACKET.
MACH' FRAME.
SIDE VIEW OF GENERATOR DRIVE
GENERATOR LEADS TO SPEED IND.
SPEED INDICATOR
PROJ' MACH' TRANSMISSION
GENERATOR
MAGAZINE HOUSING
REAR VIEW OF GENERATOR SHOWING LEAD TERMINALS

FIG. 150

ROBIN CINEMA ELECTRIC TIME SYSTEM

This system, invented by J. E. Robin in 1914, is what the name implies, a system to provide an accurate and predetermined running schedule for motion picture and synchronizing the music with same.

It is an electrical speed indicating device, consisting of a small extremely accurate direct cur-

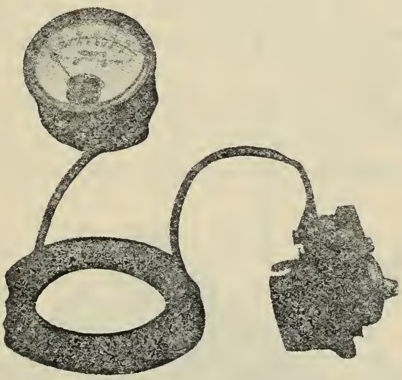


Fig. 151

rent generator attached to the projection machines and connected to a very sensitive meter by cable. The meter is calibrated with the generator and shows in feet per minute and the rate of time per thousand feet at which the film is being operated. In operation the voltage generated varies with the speed of the machine causing a corre-

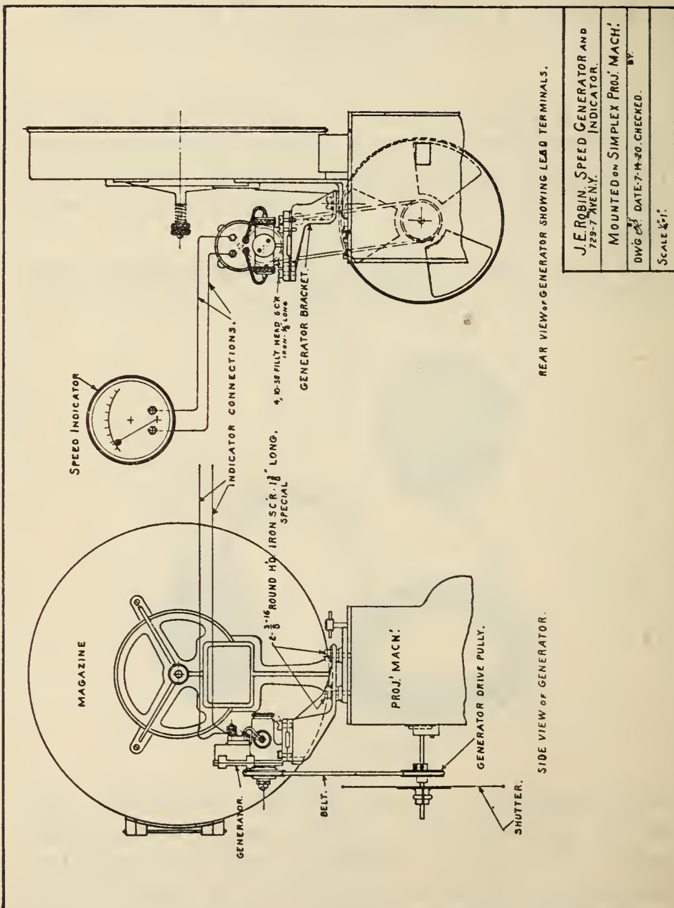

J. E. ROBIN. SPEED GENERATOR AND INDICATOR.
729-7th AVE N.Y.
MOUNTED ON SIMPLEX PROJ. MACH.
DATE: 7-14-20. CHECKED. BY.
SCALE
REAR VIEW OF GENERATOR SHOWING LEAD TERMINALS.
SPEED INDICATOR
INDICATOR CONNECTIONS.
FILLY HEAD SCR
GENERATOR BRACKET.
ROUND HD IRON SCR. LONG. SPECIAL
MAGAZINE
PROJ. MACH.
GENERATOR DRIVE PULLY.
SIDE VIEW OF GENERATOR.
GENERATOR.
BELT.
SHUTTER.

FIG. 152

sponding increase or decrease of the connected meters.

Fig. No. 151 shows a single unit consisting of a generator, meter and cable for a single machine.

Fig. No. 154 shows an equipment for two projection machines with switchboard and two meters.

Fig. No. 152 shows Robin speed indicators with switchboard as attached to a Simplex machine.

Fig. No. 150 as attached to Powers projector.

The meters and generators are made of the best materials throughout and are carefully tested prior to leaving the factory and the operator should experience no trouble whatsoever in maintaining the same.

The generators are ballbearing and contain sufficient grease to last for a year and therefore require practically no attention whatsoever.

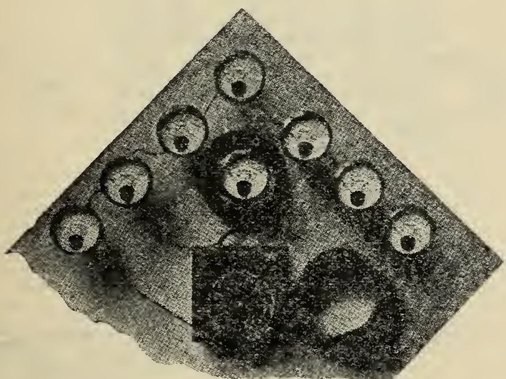


FIG. 153
Robin Signal Telegraph with Eight Synchronized Meters

In ordering speed indicators it is necessary to specify the make and type of the projection machines, the diameter of the shutter shaft and the distance for the cable required. Where it is desired to use a meter in the orchestra pit, the distance between the two projection machines and

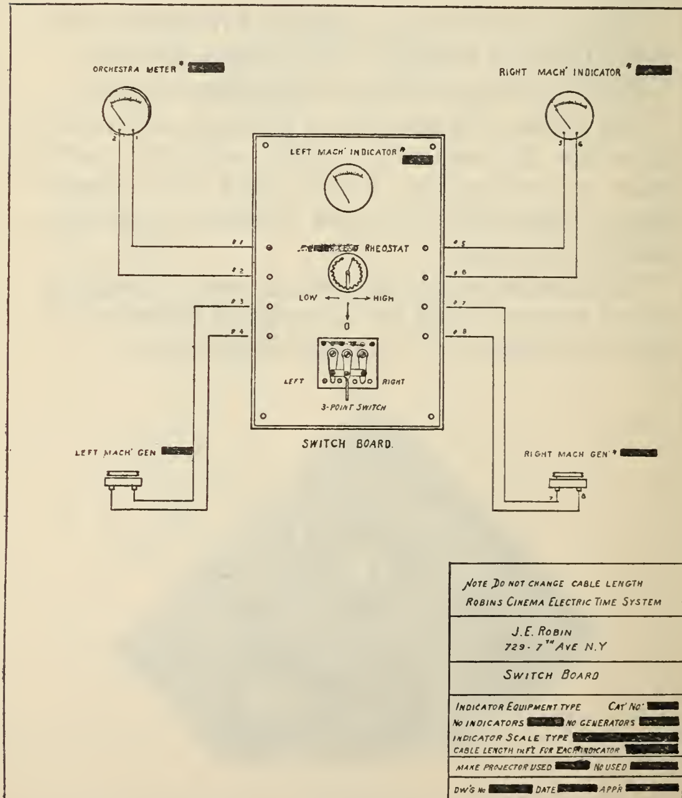
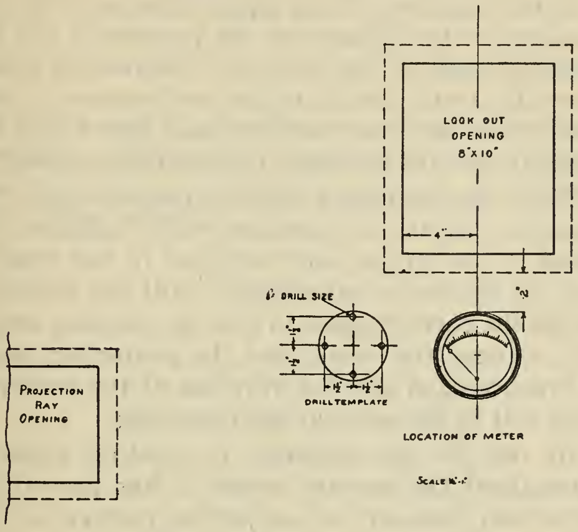


FIG. 154



FRONT WALL MATERIAL	BOLT TYPE	SIZE	LENGTH	DRILL SIZE	No USED
HOLLOW TILE	TOGGLE	1/4"	3"		4
CEMENT	EXPANSION	•			4
BRICK	"	•			4
ASBESTOS 1/2"	HEX HEAD	•	1 1/4"	9/32"	4
SHEET IRON	"	"		"	4
SLATE PANEL 1/2"	HEX CAP	•	2"	"	4

• NOTE USE SPRING WASHERS BETWEEN METER BRACKET AND NUTS

J E. ROBIN 729-7th AVE N.Y.

FIG. 155

the orchestra pit, measured on one side of the circuit, should be given.

In the majority of the larger theatres it is customary for the director to be present in the reviewing room at the time the rehearsal is made. Then the proper length of the performance is predetermined and the running speed noted, and the musical director arranges his music accordingly.

With the operating speed predetermined the operator starts his machine and regulates the speed of the projection machines in the regular way by the motor attachment until the indicator shows the correct speed in feet per minute, and in this manner the music and the projection speed is synchronized and the duration of the performance will be the same at each showing.

In use in the majority of leading theatres throughout the country where it has proved the value and necessity of projecting pictures at the

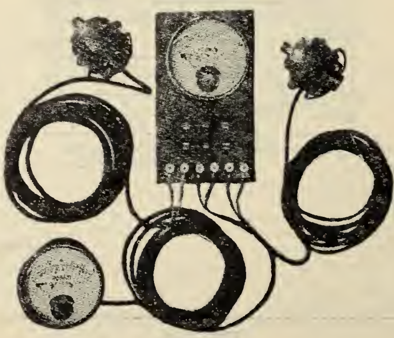


FIG. 156

Robin Indicator for Two Machines with Two Indicators

relative speed as taken, with music synchronized to support the action of the photoplay.

Fig. No. 154 illustrates switchboard and connection for equipment of two projection machines, two meters in the booth and one for the orchestra pit.

Fig. No. 155 illustrates correct position for instruments with meter underneath the lookout holes and which gives the measurements of both and drilling template.

ROBIN SIGNAL TELEGRAPH SYSTEM

The Robin Signal Telegraph system is an audible and visual signal system which provides a positive means of transmitting co-ordinated signals between the operating room, stage, and orchestra pit with certainty and dispatch.

The system consists of a master station which is placed on the stage director's stand or on the orchestra leader's desk, and is connected with the orchestra pit and meters in the booth.

The signal dispatch station consists of a panel board and a radial switch with several contacts. In operation the switch can be set at any point desired as far in advance as desired and when the button is pushed, will call the operator's attention to the signal.

At the master station is provided an instrument similar to those installed in the booth, and which serves the purpose of a master meter and conveys to the director or leader sending the signal, means of ascertaining the correct working of the system and also as a telltale of whether the instruments in the booth are registering the correct signals. If the master meter does not function, none of the others will operate.

The meters in the booth are generally placed one under each look-out hole, that the operator, no matter where located, receives the same signal. Each meter has a plate provided with a scale on which is engraved, "ready, go, stop, slower, faster, see program, light, focus, and frame."

This instrument supersedes the use of the telephone and the ordinary and troublesome return call buzzer system.

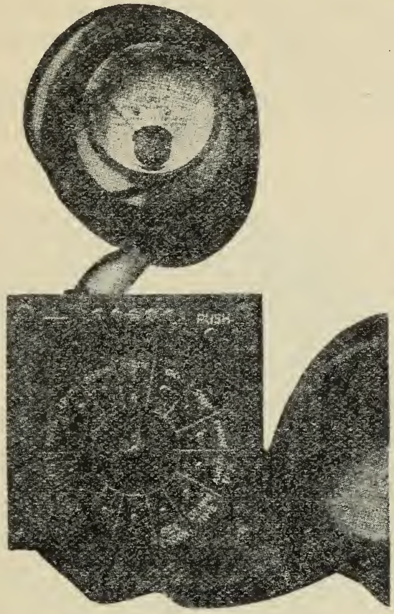


FIG. 157

In actual operation instead of the leader or stage director telephoning to the operator and calling him away from his projection machines he throws the switch over on the signal and presses the button and the operator, without leaving his position receives both an audible and visual signal.

At the rear of the control board on the master station is mounted a capirating rheostat with re-

sistance to correspond with the various points on the scale. There is also provided an adjusting rheostat to compensate any drop in voltage or differences between the points of the scale.

Wire required from the booth to the orchestra pit is five No. 16 B & S gauge wires, two for the signal and three for the return call.

The source of energy is dry batteries and one set of cells, this being sufficient for an entire year.

THE SIMPLEX SIGNAL REEL

Just how many thousands of dollars are wasted yearly in film damage due to defective reels will be hard to say, but the amount must be enormous. The peculiar part being that the film exchanges

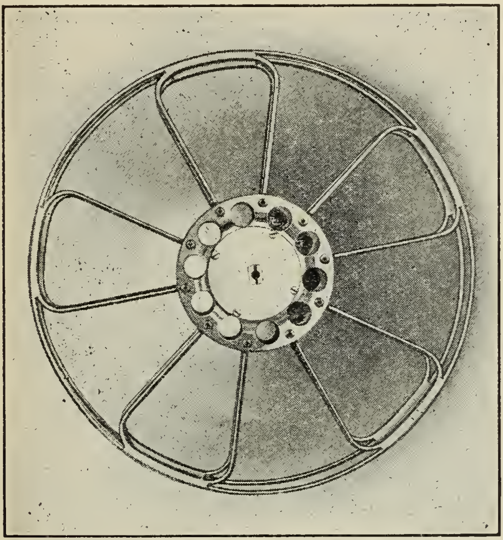


FIG. 158

are the worst offenders. Sending out features worth hundreds of dollars on reels that are in such a condition that the film has to materially suffer in passing through the projector or in transit to and from the theatre.

The Precision Machine Company, builders of the Simplex Projector, have just placed on the market a reel under the title of "The Automatic Signal Reel." This reel is so constructed that a bell is automatically rang a few seconds prior to the time of "change-over," thus giving the operator an audible change over signal.

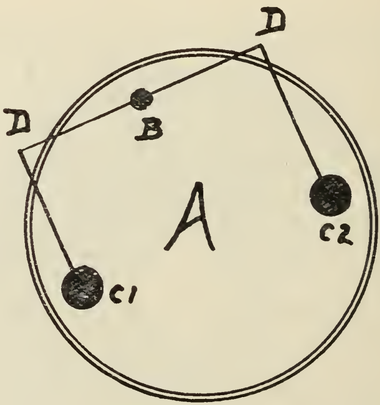


FIG. 159

The ringing of the bell is accomplished in a simple and absolute manner, Fig. 159 represents the principle of the bell ringing mechanism; A is the four-inch gong which is mounted in the hub of reel, C1 and C2 are the metal hammers that strike the gong. B is a pivot on which the hammers work, while DD are points which lock the hammers in a neutral position. It will be seen that as long as an even tension is placed on points DD (and this tension is there just as long as the

film is wound on the hub of reel) the hammers are locked in the position shown in Fig. 159, as soon as this tension is removed (caused by the film running free of the reel hub) then gravity brings down hammer C1 onto the gong, as the reel rotates gravity brings the other hammer C2 in contact with the gong and so on.

As will be seen by referring to Fig. 160 the end of the film is pulled over one of the hub supports instead of being placed under the old style spring clamp, the film is then wound back on itself thus

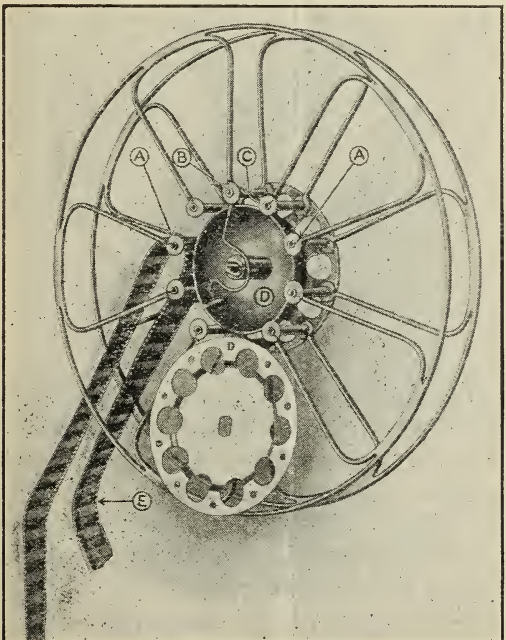


FIG. 160

locking it on the reel (and at the same time locking the hammers C1 and C2 in the neutral position shown in Fig. 159). The operator pre-determines just how long prior to the "change-over" the bell shall be rang simply by pulling more or less of the free end of film over the hub supports.

Suppose the operator wishes the bell to start ringing three seconds prior to the end of the film,

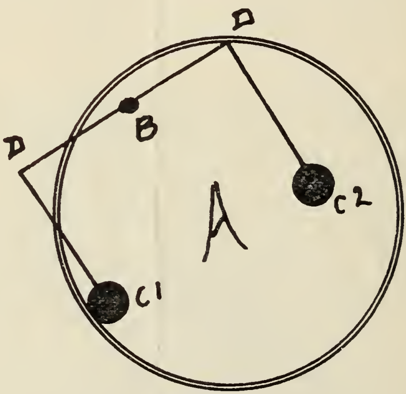


FIG. 161

all that he has to do is to pull three feet of film over the hub support—based on the assumption that the film is being driven through the projector at the rate of sixteen frames (1 foot) to the second—which means that three feet from the end of film the tension on the gong hammer will be released and the bell rang.

The reel is light in construction yet very strongly made, the sides are made of cold rolled

spring wire which eliminates all rough, sharp edges saving both the film and the operator's fingers. As will be seen from the photographs, the construction of the reel allows ample room for threading. The hub proper is made from a solid

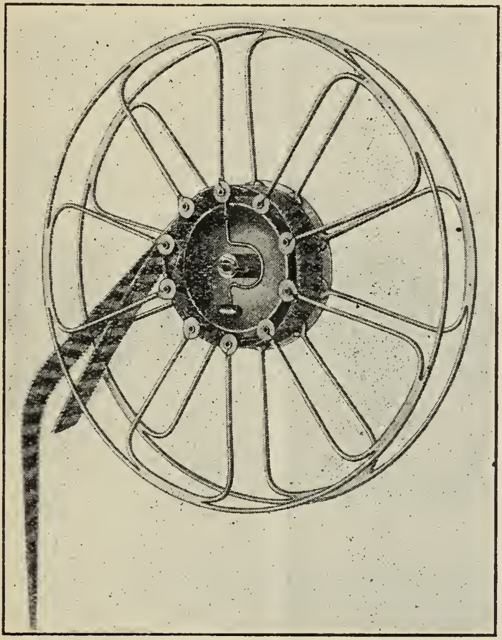


FIG. 162

cylinder of steel and the keyway is drilled very deep, provision has been made to allow a new keyway to be fitted should this be necessary. Personally, I cannot see how a new keyway will be necessary as with ordinary wear and tear it should last the life of the reel.

While the reel is of light construction, it is very strongly made, it will be found difficult to bend it out of shape. It is, without doubt, the most serviceable, best constructed reel yet drawn to the writer's attention. You can get rid of all your reel troubles by getting in touch with the Precision Machine Company. I believe the reel can be obtained without the change-over signal if desired.

PORTABLE PROJECTORS

The portable projector has made a permanent place for itself in the motion-picture industry, several hundreds of this class of machine are in daily use in studios, cutting-rooms and viewing rooms, salesmen are using them to help sell their wares. Motion pictures are becoming a part of the curriculum in churches and schools through the medium of the portable projector. This type of machine has been brought to a high stage of perfection, it is now possible to get a complete motor-driven motion-picture machine enclosed in a carrying case measuring approximately 18″x17″ x8″ and weighing about 25 lbs, and this compactness has not been obtained by sacrificing accuracy. Portable projectors are built along various lines,

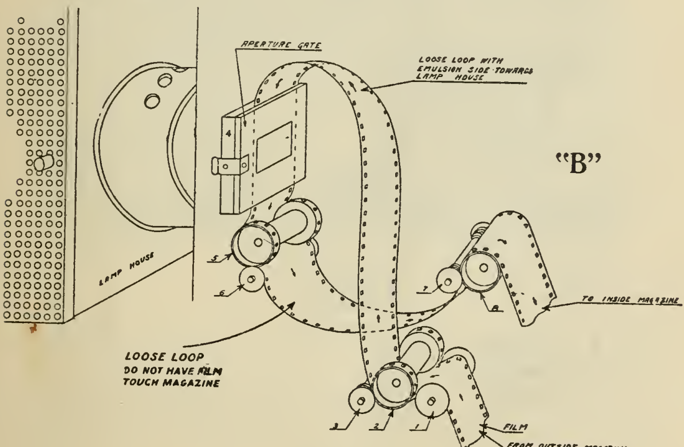


FIG. 163

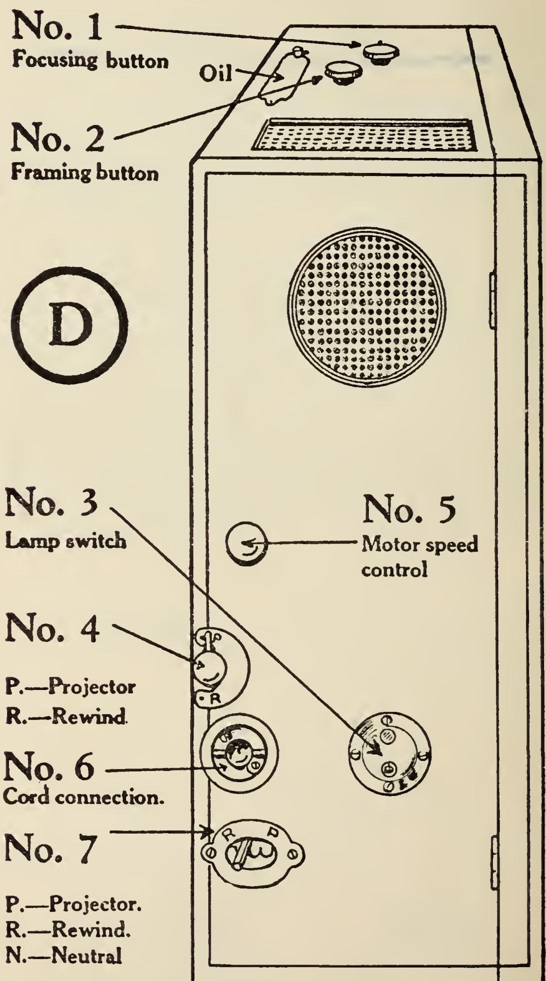

No. 1
Focusing button
Oil
No. 2
Framing button
D
No. 3
Lamp switch
No. 5
Motor speed
control
No. 4
P.—Projector
R.—Rewind.
No. 6
Cord connection.
No. 7
P.—Projector.
R.—Rewind.
N.—Neutral

FIG. 164

each manufacturer having his own ideas on this subject, and to attempt to describe each type in a work of this kind would prove to be a hopeless task, we will however devote a little space to the handy suitcase model.

THE ACME PORTABLE PROJECTOR

To thread the Acme pull out the round film guard between the gate marked No. 4 and the lens, push down the three guide rollers numbered

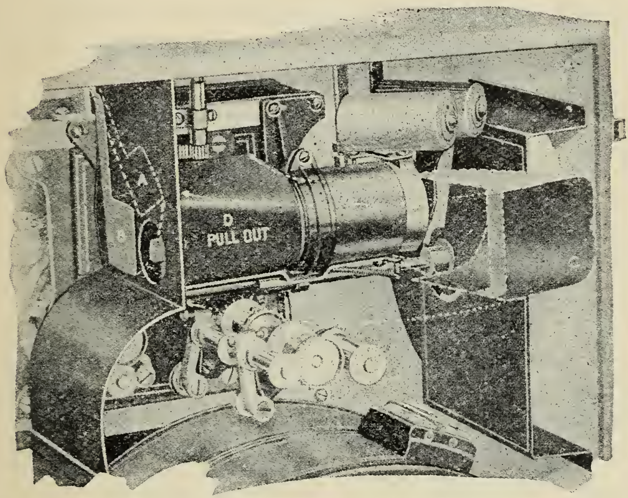


FIG. 165

The Safety Shutter (B) drops and covers the aperture plate opening, cutting off the light rays, whenever the Acme is not being operated. While the machine is being operated the Shutter is held by centrifugal force in position shown by dotted lines "A." In threading the film, the "pull-out" (D) is opened into position C, thus allowing the greatest accessibility in getting the film in place. But as soon as the film is threaded this "pull-out" slips back into place and is held there by a coil spring, preventing any of the film from ever getting in the path of the light

3, 6 and 7 in diagram "B" these are shown in diagram "C" in open position. Next open aperture gate by lifting spring catch on gate number 4 towards you, this is done through the small round hole in the division plate between the lamp house and projector. Next open the magazine by pushing down on the catch, swinging the outer half outwards so that the magazine when open hangs at right angles from the projector, then place the full reel of film on the shaft of the outer magazine, turn clip on this shaft down to keep reel in place. Next draw the film through the rollers and pull towards you. The emulsion or dull side must be face upward, and three feet of

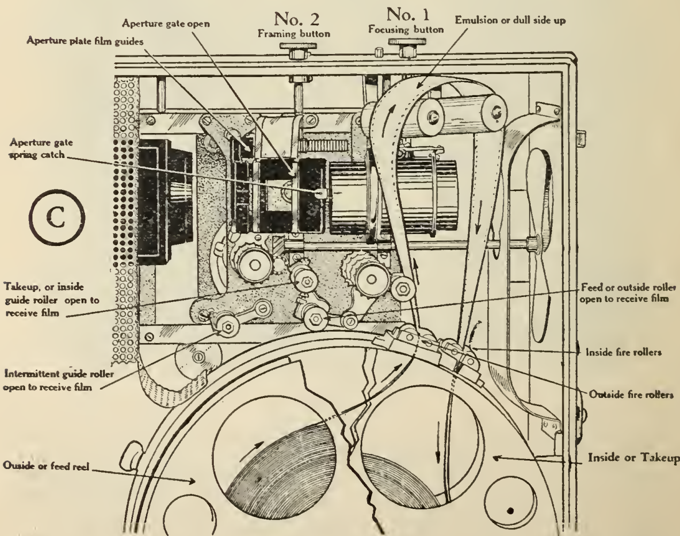


FIG. 166

film should be drawn from the outer magazine in order to thread the Acme, then partly close the outside magazine, place the film over the top of stationary guide roller No. 1, under film sprocket marked No. 2 making sure that the perforations are over the teeth of this sprocket, then push up guide roller No. 3 into place; the film is in correct position when it is between sprocket No. 2 and roller No. 3 as shown in diagram "B." Now make a loose loop that is also shown in diagram "B." placing the film in the aperture plate marked No. 4, close aperture gate and see that the spring catch on it is securely fastened. When the film is placed in the aperture plate correctly the picture must be upside down with the emulsion or dull side towards the lamp house. The film must now pass in front of sprocket No. 5 as shown in diagram "B." The perforations must be engaged on the teeth of the sprocket. When this is done push guide roller No. 6 into position as shown in diagram "B." This same diagram shows a loose loop between sprocket No. 5 and sprocket No. 8; this is imperative. This loop must be as large as it can be made without touching the round magazine underneath it. Place the film underneath the guide roller No. 7 and over the top of sprocket No. 8. When this is done close guide roller No. 7; now you have the projector mechanism threaded —open the outer magazine, which can be done while the film is in it. Place film from sprocket No. 8 through the slot of the inner magazine between the magazine rollers. Take the end of film; place it underneath the spring clip on the center of the empty reel hub, give it one turn to securely

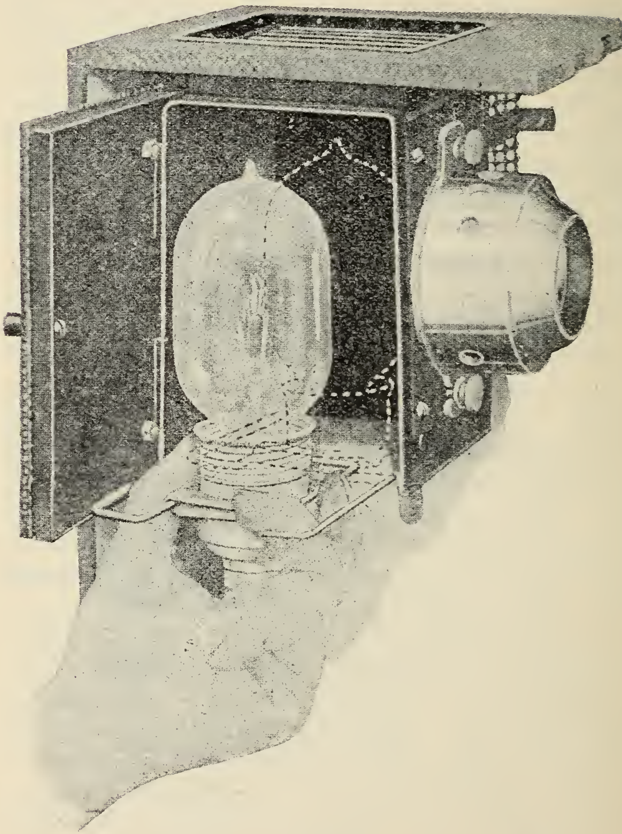


FIG. 167

If desired you can change the lamp in the Acme in a few seconds—merely slide it out of its housing, as shown in the illustration. Both up-and-down and horizontal adjustments are made by simply loosening the screws, getting the adjustment you want, then tightening them again. The Condenser, in case it needs cleaning, is easily removable by merely loosening the two thumb-screws

fasten the film, place this reel on the inner magazine shaft, be sure that the slot in this reel slides over the key on this shaft. When in position turn down clip on the end of shaft to hold this reel in place. The direction of travel on this inner reel is always towards the right. Then close outer magazine, machine is now ready for operation.

To operate, insert connection plug in opening No. 6 at back of case. See that indicator on bottom No. 4 points to "P," (Picture) ; also that lever No. 7 is at "P."

Push in the button on switch No. 3. This lights the lamp. Then turn button No. 5 slowly to right. This operates the motor and any speed desired may be obtained by merely turning it. To stop machine turn back to left.

Button No. 1, on top of the projector, operates the focusing device, and if you cannot get the image sharp by turning this button, open the case door and adjust the lens tube in the lens jacket by moving it forward or backward with your hand until the right effect is obtained.

Button No. 2 operates the framing device, and by turning in either direction it enables you to frame the picture instantly. If you do not see the full picture on the screen, simply operate button No. 2 to locate correctly.

To rewind after using, be sure light is turned off; take off the full reel from inner magazine shaft. Remove empty reel from outer magazine. Stand full reel on rim, with end of film toward the right. Now wind end on hub of empty reel, dull side outward, securing end firmly with a few

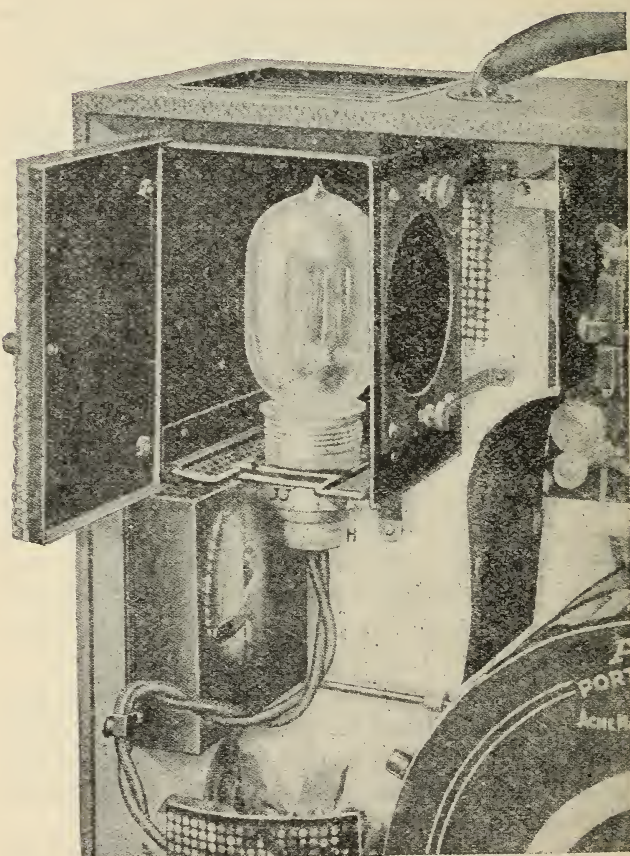


FIG. 168

The simple button (on outside of case) moves the rheostat up and down, as shown by the dotted line in the illustration, thus giving practically any speed required

turns. Now place empty reel on inner magazine shaft, slipping film through magazine rollers. Loop film over the two wooden rollers in top of case as shown in Fig. "C." Turn down clip on inner shaft holding the reel in place. Bring outer magazine around to closing position, threading film through magazine rollers, placing reel on shaft, again turning down clip on shaft to hold reel in place. Close and lock outer magazine. At

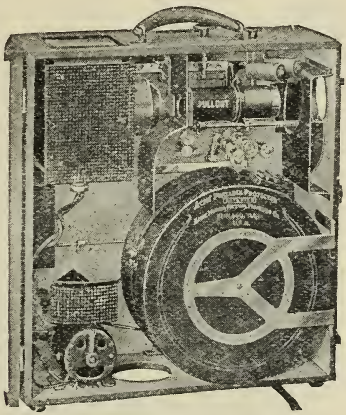


FIG. 169

Photo Showing Compactness of Portable Projector

back of case, turn indicator on button No. 4 to "R."—Rewind. Turn also lever No. 7 to "R."—Rewind. Then turn button No. 5 to right—slowly —to operate motor for rewinding.

CAUTION

When through rewinding, always turn the indicators on buttons No. 4 and No. 7 to the letter

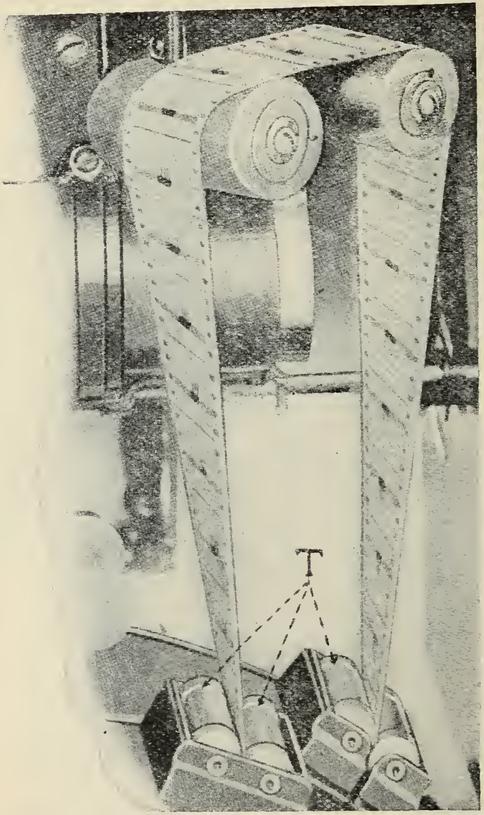


FIG. 170

When the reel has been run through the Projector (and must be rewound to be run again), you merely transfer the reels on the feed and take off shafts, run the film over the two wooden rollers, and turn the button releasing the motor. None of the projecting mechanism is used for this purpose, but remains at a standstill during the rewinding operation

"P"—Picture—before making ready for the next projection.

OPERATING BY HAND

To operate the Acme Projector by hand, all that is necessary is to move the lever No. 7 to the center groove which releases the motor.

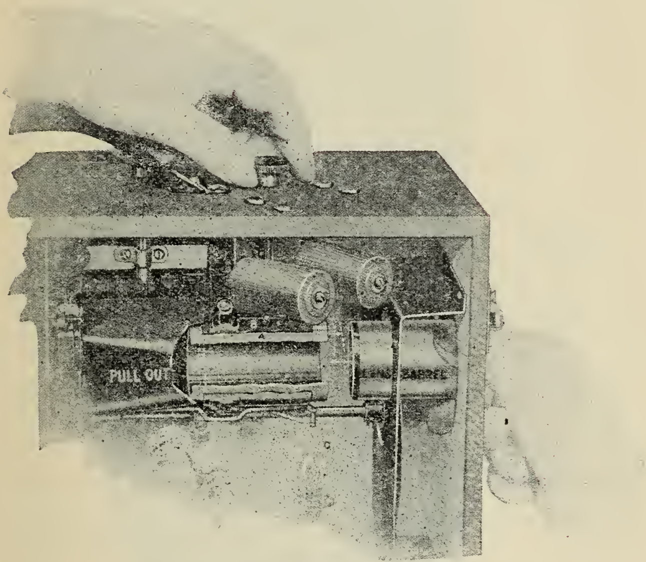


FIG. 171

The lens barrel is easily taken out through the front opening without having to remove shutter or any other part. This lens barrel merely slides into the lens jacket (A), and this jacket is moved forward or backward (in B) by the button on top of case. Correct focus for any distance may be obtained by sliding the lens either way within this jacket

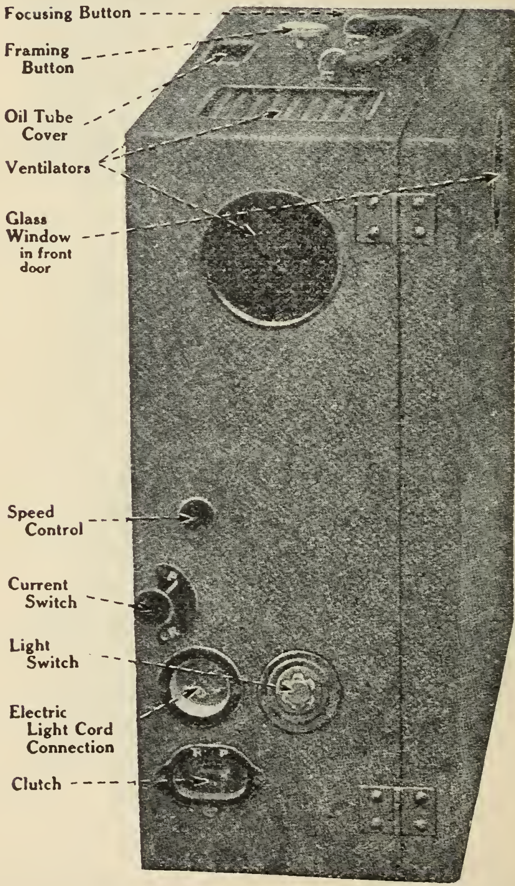


FIG. 172

Rear View Showing Adjustments and Controls

OILING THE PROJECTOR

On the top of the machine case you will notice a small oblong opening that has a metal slide door, push back this slide and you will find four oil tubes directly underneath it. These four tubes lubricate the bearings in the back of the mechanism. The motor has an oil tube coming through the perforated guard that leads to its inner bearing. The top of the fan has a drilled screw—this is for oiling. On the end of the fan bracket you will notice two fibre pulleys. Between these two you will find an oil hole which lubricates them. There is an oil well on the outer end of the motor which is very accessible. The inside of the two shafts in the magazine must have oil—you will find oil holes there for same. On the mechanism you will find on the shutter shaft two nickel plated brackets with holes for lubricating. You will find oil holes on shaft bearings of feed and take-up sprockets—the intermittent sprocket has a bronze bushing with oil hole in same, to get at this, slide the mechanism forward as far as it will go. On side of case opposite door in about the center close to the bottom is a round hard rubber bushing, you will find the shaft for double idler pulley right inside this hole; this must have oil very often, in fact all bearings should have a drop of oil each day before operating machine.

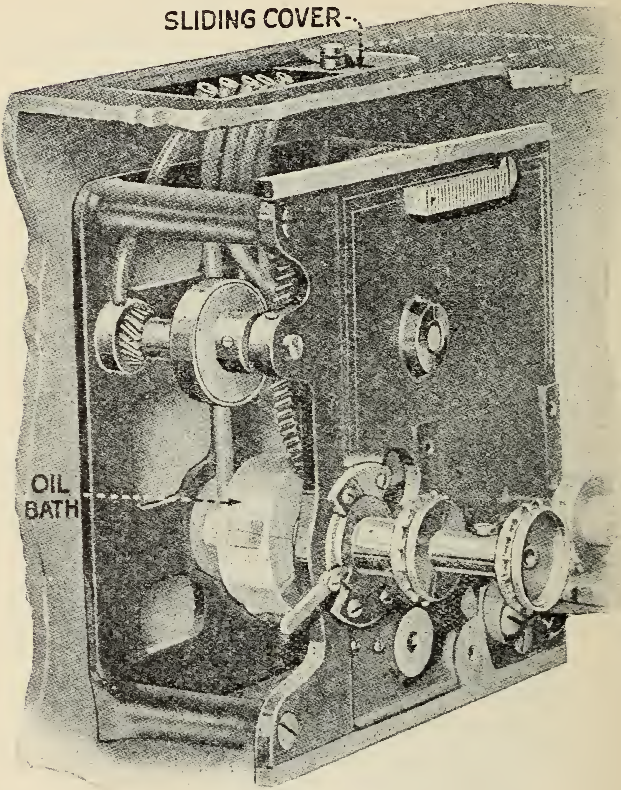


FIG. 174

On top of the case is a sliding cover, just beneath which are five oil-tubes, each leading directly to an oil-hole at some bearing. The motor shaft and belt pulleys are also provided with similar oil-tubes. The intermittent mechanism is of the Geneva type and *runs in an oil bath.* The Acme intermittent movement can be adjusted without having to remove the mechanism from the case

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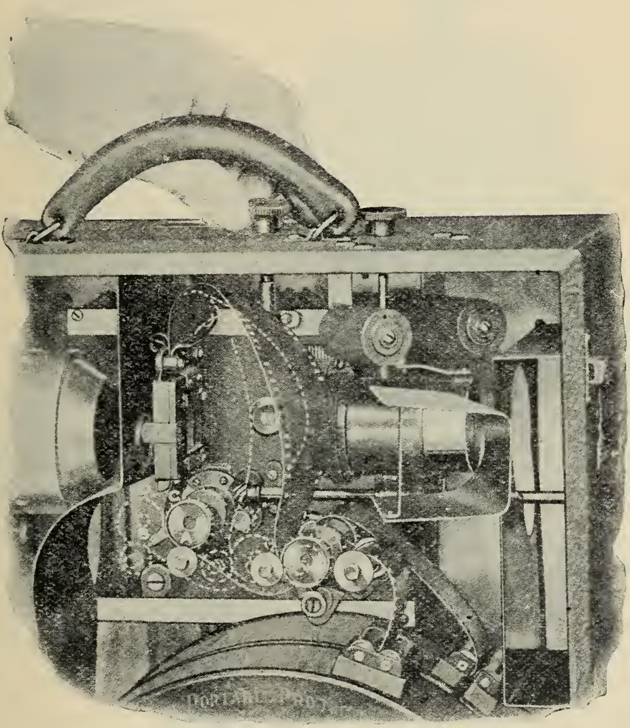

FIG. 175

Merely turning the button on top of the case in either direction frames the picture instantly. The illustration shows that, in framing, the aperture plate and lens remain absolutely stationary—the movement, forward or backward, of the mechanism adjusts the relative position of the picture until it "frames" correctly

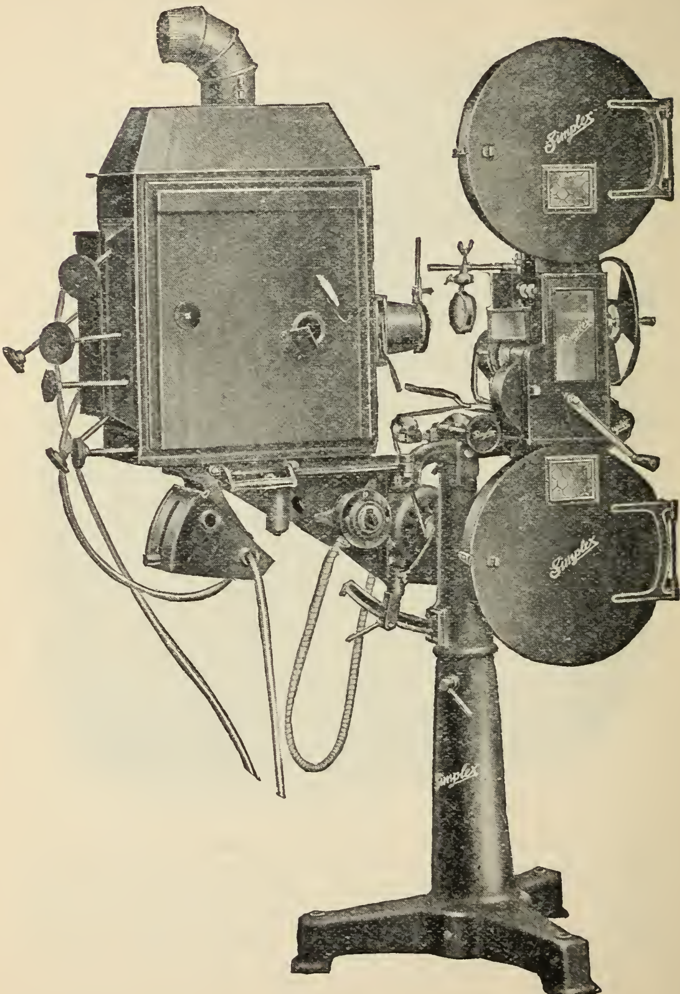

FIG. 176

Simplex Type "S" Projector

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INSTRUCTIONS FOR INSTALLING THE SIMPLEX PROJECTOR

UNPACKING

Upon arrival of the machine use utmost care in unpacking.

Use nail puller in opening case and removing all nails used in securing cleats supporting different parts.

Never use a hammer to knock out cleats.

Cleats removed; parts can be lifted out one by one.

Pay special attention when removing Mechanism from case.

Don't take hold of shutter shaft to lift it out.

Take hold of bottom with right and top with left hand thus lifting it out of case.

Unusual strain will bend shutter shaft.

Simplex Machines while simple and strong in construction, are a carefully adjusted piece of mechanism and cannot be handled roughly beyond a certain limit.

SETTING UP SIMPLEX PROJECTOR

A. Assemble pedestal column to base.
Have two feet of base face screen.

B. Fasten lower magazine and take-up to base.
Use two screws furnished for the purpose.

C. Fasten mechanism to pedestal top by means of two wing screws.

D. Attach upper magazine to top of mechanism.

E. Assemble Lamphouse to carriage just back of Mechanism.

CONNECTING UP ASBESTOS LEADS

D. C.

Attach three (3) ft. wire to Lamphouse and lower switch box terminal.

Attach four (4) ft. wire to opposite lower switch box terminal and to one side of rheostat.

Attach six (6) ft. length to other side of rheostat and connect other end to upper carbon holder.

A. C.

In connecting transformers or current savers, connect wires from main line switch or wall switch to upper terminals on pedestal switch. Now connect two wires from lower terminals on above switch to primary winding of whatever transforming device is used, which will be found marked "line." Then connect two wires from terminals marked "lamp" on the transforming device, after which connect other two ends of these two wires to the upper and lower carbon holders inside of lamphouse.

CONDENSER

Place 6½ in. condenser toward arc and 7½ in. toward screen.

LENS ASSEMBLY

The flat surface of the moving picture lens should face the arc; the bevel side of the screen. This also applies to achromatic lenses.

SHUTTER, STERNO LENS HOLDER AND FRAMING DEVICE

Shutter should be placed on shutter shaft in front of mechanism in accordance with instructions in following pages.

The framing handle should be inserted in framing device on lower part of mechanism facing lamphouse.

Take lens holder, insert lens between adapters, tighten with holder ring and fasten to upper part of mechanism away from operator with stereo rod inserted in stereo arm.

ATTACHING MOTOR

For the attaching of the Motor Table a slot will be found on the left of the pedestal column, nuts and washers for fastening same are furnished.

Two sets of holes will be found on Motor Table, either set of which may be used according to drive. When using old style drive in conjunction with pedestal pulley, use inner set of holes. If motor is to be used in connection with new speed control, use the outer set. Two 5/16 in. wing screws are furnished for fastening motor to table. After attaching motor to table, fasten snap switch to slide over arm for which three holes are provided. The canvasite cord attached to the snap switch should then be connected to the line intended to furnish power for the motor by means of an attachment plug or other device. On AC when using constant speed induction motor furnished with the new friction speed controller, a 10 ampere fuse is recommended, as this motor requires about three times the normal running current for starting under full load.

On DC Motors a three ampere fuse is of sufficient capacity and is recommended for the protection of the motor.

Lower magazine has a reversible take-up pulley with two grooves. The large groove should be used with the long take-up belt for large reels, 5-in. hub, taking 1,000 ft. of film or over. The small groove should be used with the small take-up belt with reels having small hub. If take-up does not work properly, reverse pulley, you may have it on wrong.

A FEW FACTS CONCERNING THE SIMPLEX

The same optical distances prevail in the new Simplex Mazda achievement as are used in the carbon arc projector.

Lamphouse sets the same distance from mechanism as does the carbon arc housing.

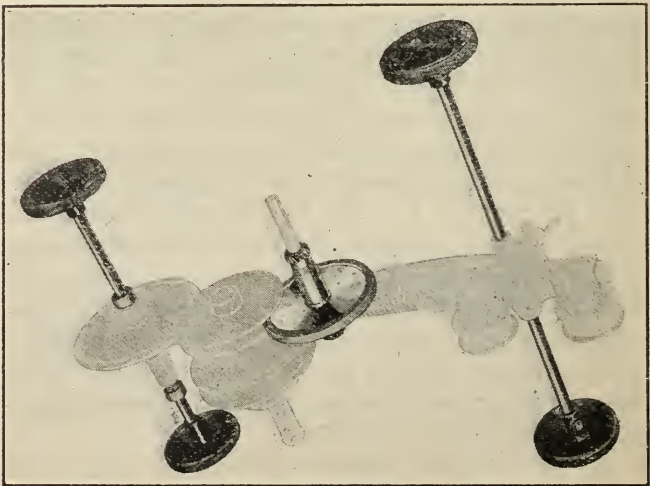

Fig. 177

Simplex Improved Speed Control

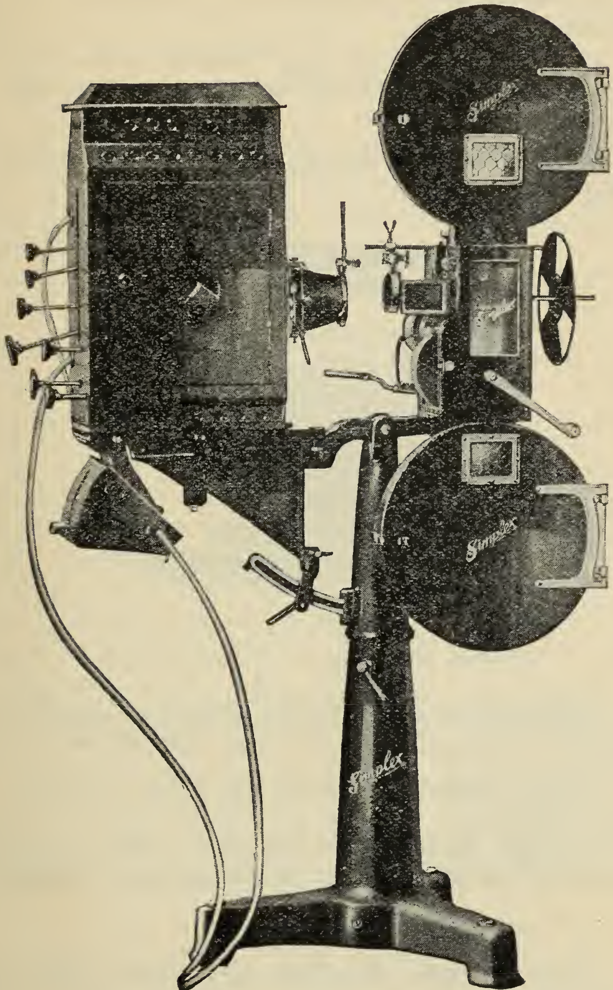

FIG. 178

Simplex Type "B" Projector

Regular plano condensers are employed in this system.

All important adjustment handles extend outside of lamphouse, thereby eliminating the heating up of same.

Special filament "lining-up" device attached to lamphouse door.

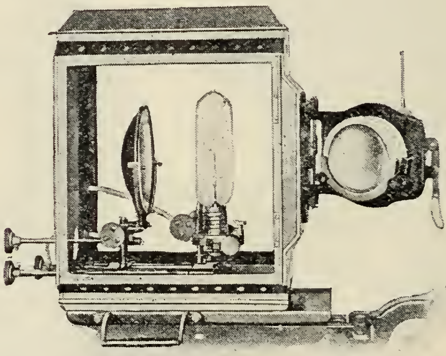

FIG. 179

Simplex Lamphouse for Mazda Projection

Supplementary lamp holder already adjusted for instant use furnished with every lamphouse.

Optical system provides for added screen illumination.

Simplex Mazda housings fitted with special brackets for use on other projectors are available.

THE TAKE UP

There's no need of telling the Operator that the Take-up Shaft is a mighty important part of a Projector.

It absolutely must not fail him; and to be proof against going back on him it must be designed right in the first place.

Now, there are two ways of designing a Take-up Shaft.

One way is to design it wrong, to have the belt pull sideways on the shaft, cramping it in its bearings, and then to try to overcome the difficulty by introducing ball bearings.

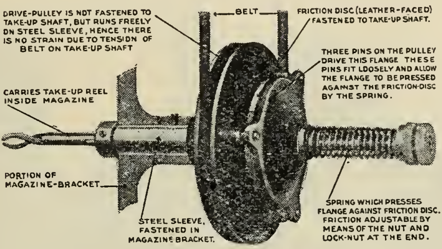

FIG. 180

The Simplex Take-up

The other way is to design it correct in principle, like the Simplex Take-up Shaft here illustrated.

When you read the explanations you will quickly see that the belt-pull doesn't come on the shaft at all; so there's no cramping or friction to try to reduce by "anti-friction" bearings.

And, as you know, the probability of any piece of mechanism going wrong increases directly as the number of parts it contains. So being extremely simple as well as free from blunders in

design, the Simplex Take-up Shaft is dependable in the highest degree.

THE INTERMITTENT MOVEMENT

The Simplex embodies the "star and geneva" movement, this principle being as highly refined as is possible to do with the best procurable material and precision workmanship.

No other intermittent movement has yet been evolved which compares with the geneva move-

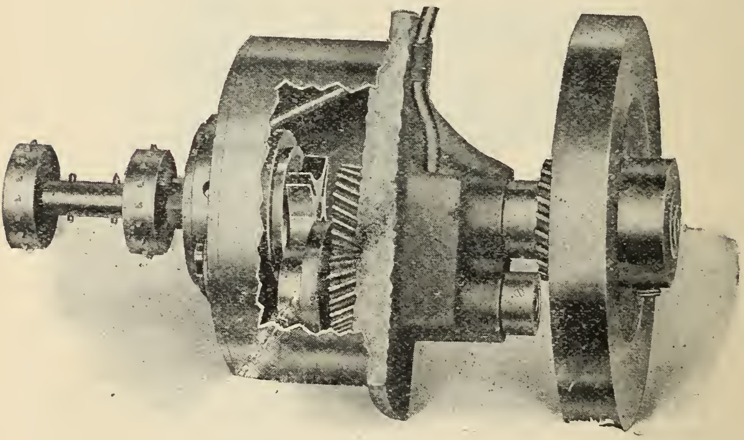

FIG. 181

The Heart of the Simplex

ment for accuracy, length of wear and yet allows for perfect adjustment to compensate for any amount of wear.

Movement lies in oil chamber, the lubrication for which is conveyed through oil tubes easily accessible.

Shafts and sleeve bearings are ground fit, insuring long service and perfect fit and alignment.

Adjustment of star and cam is made by means of eccentric bushing and by use of fork wrench without removing any portion of the mechanism.

Complete intermittent unit may be removed entirely and replaced in two minutes, only tools required for so doing being screw driver and pliers.

Casing is absolutely dust-proof, insuring against abnormal wear.

All mechanism adjustments that are most generally used are located within easy reach of the user's left hand.

1, 2, 3—Are used for making all stereopticon adjustments.

4—Focuses the projector lens which is contained within the mechanism, this method of focusing doing away with the common practice of reaching in front of the mechanism to focus lens

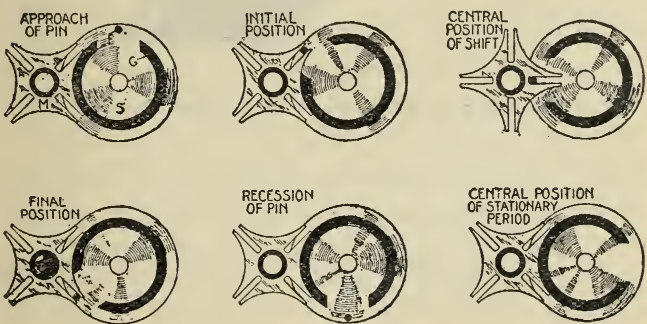

FIG. 182

Diagram Showing Progressively the Operation of the Geneva Intermittent Movement

and the attending danger while so doing of knocking against revolving shutter.

5—Indicates knob which locks door cover lower loop.

6—Enables the user to adjust shutter while machine is in operation, this being an exclusive Simplex feature.

7—Indicates frame lever so arranged to give perfectly balanced leverage with the least possible exertion.

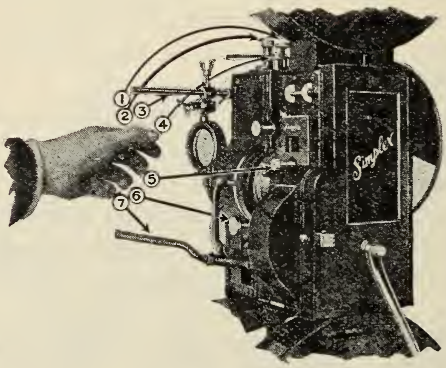

Fig. 183

Accessibility of Adjustments on Simplex Projector

VARIABLE SPEED CONTROL

INSTALLATION AND OPERATION

When it is desired to change from hand driven machines to motor driven, simply loosen up the set screw (three turns) which holds the motor drive pulley shaft in the lug on the base of the mechanism frame. The driving shaft on the speed control, S-575-X (page 523), which has a small gear on it, is then inserted into the hole in the lug on the base of the mechanism frame.

In attaching the device, it is very important that care should be taken to mesh the gear on the shaft of the speed control S-575-X with the main driving gear on the mechanism. The set screw should then be tightened. At the same time the idler pulley shaft on the pedestal fits into the opening on the right of the speed control, and is tightened with the knurled head or wing screw from underneath, but the set screw to hold the driving shaft should be fastened first. Fasten the right end of the speed control at whatever position it takes on the idler pulley shaft on the pedestal. Do not force it into position, as it may cause the gear on the speed control and the main driving gear to bind, and eventually ruin them by wearing unevenly. The important thing is to see that the two gears mesh properly and the remainder of the speed control will take the position which will give best results.

To install the device on motor driven machines you have to remove the motor drive pulley on the

main driving shaft, also the idler pulley on the pedestal shaft. Place the speed control on the machine in the same manner as described above for changing from hand driven machines to motor driven.

The present D. C. Motors can be used by making a slight alteration in them, but in the case of alternating current, a new constant speed induction type of motor is provided. This abolishes the commutator type of motor and means lower maintenance costs and longer life of motors.

The arrangement of the belt for the speed control is shown in the accompanying illustration,

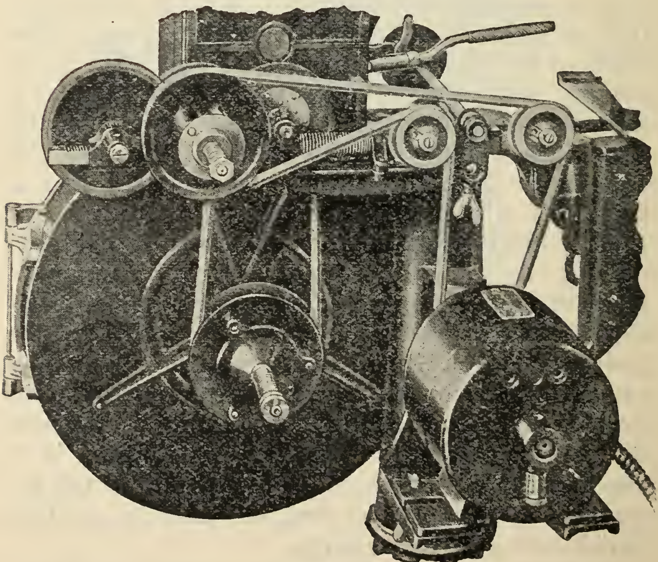

FIG. 184

Variable Speed Control

Fig. 184, better than could be described in a few words. The illustration amplifies the description for placing the speed control on the machine.

It may be advisable, however, to give a few details in connection with the operation of the device.

The variable speed control is operated or controlled by Handle S-438-M (page 523). By turning this handle either to the left or right, the movement of it either tightens or releases the Tension Spring F-119-X and moves the friction disc S-218-L. This friction disc S-218-L operates between the two other discs X-7 and D-118-X. At any time, it is only the rim of the friction disc S-218-L that comes in contact with the other discs X-7 and D-118-X. When the handle is turned so that the contact of the friction disc is near the center of the other discs, the speed is low because the contact is almost at the center of the circle of the two discs and revolves on a small circumference. As the friction disc S-218-L is moved out near the edge of X-7 and D-118-X the circumference of the circle increases, and the speed is correspondingly increased.

It is absolutely necessary, if the friction disc S-218-L is to drive the control and the mechanism, that it have a friction contact.

No oil of any description can be used on the friction discs or the other discs. And, further, as oil may accumulate on these discs from time to time from the shaft, the discs must be wiped off occasionally. As soon as the oil accumulates, friction is eliminated, the speed reduced and the device may stop entirely. A small amount of vase-

line may be applied to the fibre disc occasionally; it should, however, be wiped clean after applying.

It also must be borne in mind that the nuts N-136-X holding the spring on the shaft S-470-X must not be tightened too much; just enough to catch the thread sufficiently to hold the spring, as

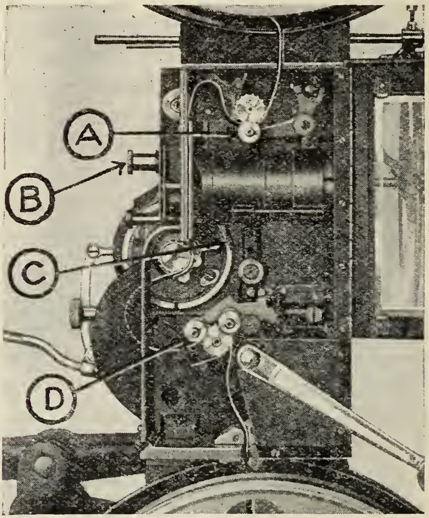

FIG. 185

a very little pressure on the discs is required to run the control.

In changing the speed, the idler pulley moves with the tension spring F-119-X, and adjusts the belt so that no matter what speed is required, the belt adjusts itself to requirements.

THREADING SIMPLEX

To thread the film through the Simplex head, open up film rollers A and D, Fig. 185, open gate

by pressing plunger B; now draw out of upper magazine through magazine valve about three feet of film, pass film under top feed sprocket and close film roller A, thread through gate, making sure that the film is riding on runners; engage film on teeth of intermittent sprocket, then close gate by tripping catch C; next pass film over lower feed sprocket and close film rollers D, thread through the lower magazine valve and engage on clip on lower reel. Care must be taken to see that a loop of film is formed between the upper sprocket and gate, and between the intermittent and lower sprocket.

BEFORE STARTING YOUR SHOW

See that—

Carbons are long enough to last through the picture.

Lamphouse is free from grounds.

All electrical connections are tight.

Arc is not burning upside down.

The light spot is focused on aperture in gate.

Projector is oiled, intermittent bath is full, grease cups are filled and are feeding.

Magazines are lined up with mechanism, so that film travels in a straight path from top to lower magazine.

Take-up tension is all right, if using Simplex-Boylan reels, see that take-up on machine is out of commission.

Sprockets are free from dirt; remember that dirt on the intermittent sprocket may cause jumping of the picture on the screen.

Tension springs on gate of projector are adjusted properly.

There is no deposit of emulsion on the tension springs and shoes.

Light or revolving shutter is synchronised with intermittent sprocket.

Reels on which films are wound are in such a condition that the film runs off same unhampered.

Lenses and condensers are clean.

Picture is in focus, and in frame.

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INSTRUCTIONS FOR SETTING UP SIMPLEX MAZDA EQUIPMENT

THE CONDENSERS

Condensers (J—Fig. 186) will be found wrapped with paper covering. Note that sizes of condensers (6½ and 7½) are plainly marked on wrappings.

Unscrew condenser rings (M—Fig. 186) and drop condensers into same carefully.

Screw condenser holder ring back into place securely enough to hold condenser. Great care must

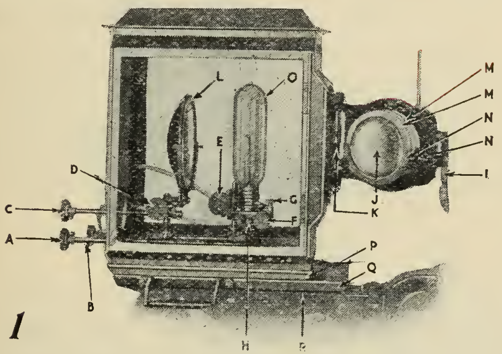

FIG. 186

be taken against tightening this ring too firmly, as by so doing will bind condenser and prevent expansion when same becomes heated, resulting in possible breakage.

When this has been done condenser holders con-

taining condensers are then dropped into containers (N—Fig. 186) with rounded or convex surfaces facing one another.

Note that the 6½ condenser sets in container nearest the lamp and the 7½ condenser sets in container nearest the film.

Now swing condenser mount back into position, locking the same by engaging handle (I—Fig. 186) with lock (K—Fig. 186).

PLACING LAMPHOUSE ON MACHINE

Lamphouse is now placed on swinging table, making sure that sliding base (P—Fig. 186) sets

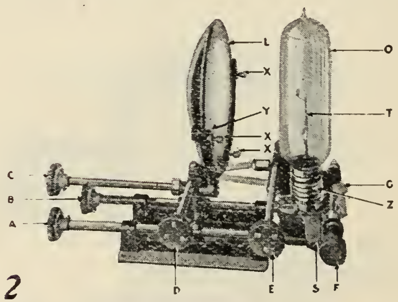

Fig. 187

accurately into base groove (Q—Fig. 186), then fasten lamphouse to base with wing screw (R—Fig. 186).

SETTING LAMP IN HOLDER

Loosen knob (H—Fig. 186), turning same out to its fullest extent, then screw lamp (O— Fig. 186) into its socket, as far as possible.

Adjust lamp so that filament (T—Fig. 187) is parallel with knob (F—Fig. 187). This lining up of filament is imperative and absolutely necessary in procuring correct focus, as will be later described.

When proper alignment has been made, tighten knob (H—Fig. 186) firmly; this operating rigidly secures lamp into required position (see illustration, Fig. 189).

INSERTING LAMP AND HOLDER INTO MECHANISM

Lamp and holder are now ready for inserting into lamphouse.

Hold knob (F—Fig. 189) and thumb piece (S—Fig. 189) securely between thumb and forefinger of the right hand.

Insert lamp slowly into position, making sure that collar (U—Fig. 189) engages with rod (U-1—Fig. 195), and also note that contact strip (V—Fig. 193) engages between slot and contact holder (W—Fig. 193), pushing in as far as it will go.

INSERTING MIRROR

We have now reached that stage where the mirror plays an important part in our system.

Clean and polish mirror carefully with clean soft tissue paper.

Now loosen thumb screws (X—Fig. 187) and insert mirror (L—Fig.186) carefully into holder (Y—Fig. 187), tightening thumb screws (X—Fig. 187) only sufficiently to hold mirror in place without undue pressure.

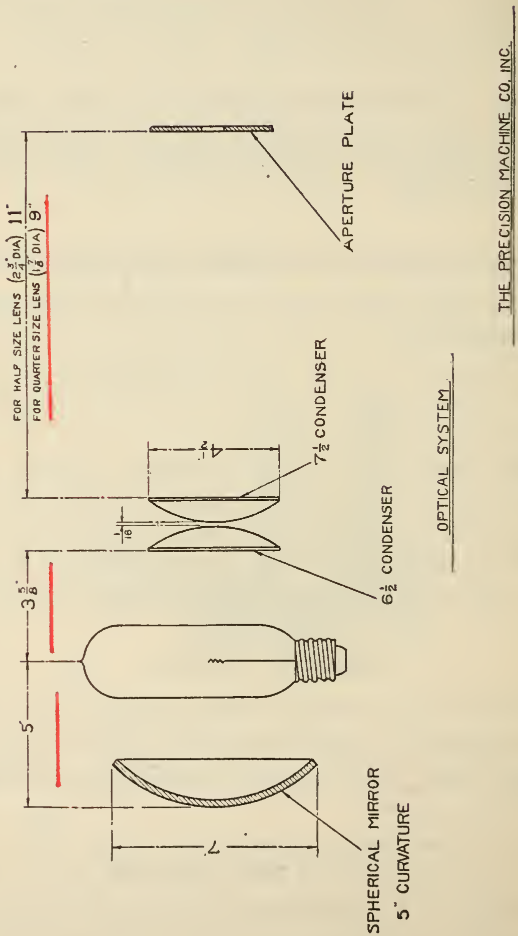

FIG. 188

Simplex Mazda Wiring Diagram

FOCUSING MIRROR

The distance from the center or back of convex surface of mirror and the filament (T-2) of the lamp should be approximately five inches, as shown in Optical Diagram (page 492).

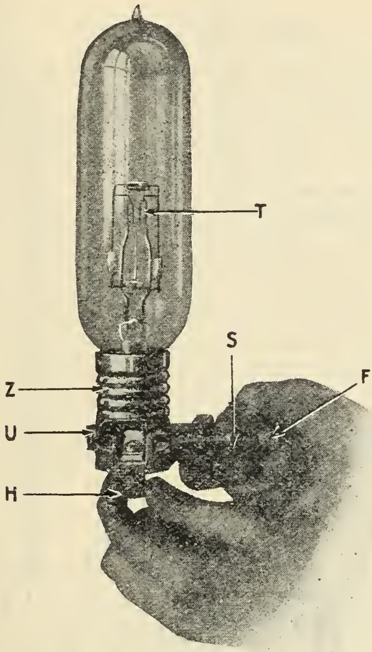

FIG. 189

This distance is obtained by operating knob (A-1) either to the right or left as occasion may require.

Now unlock mirror holder by turning knob (D-1) to the left.

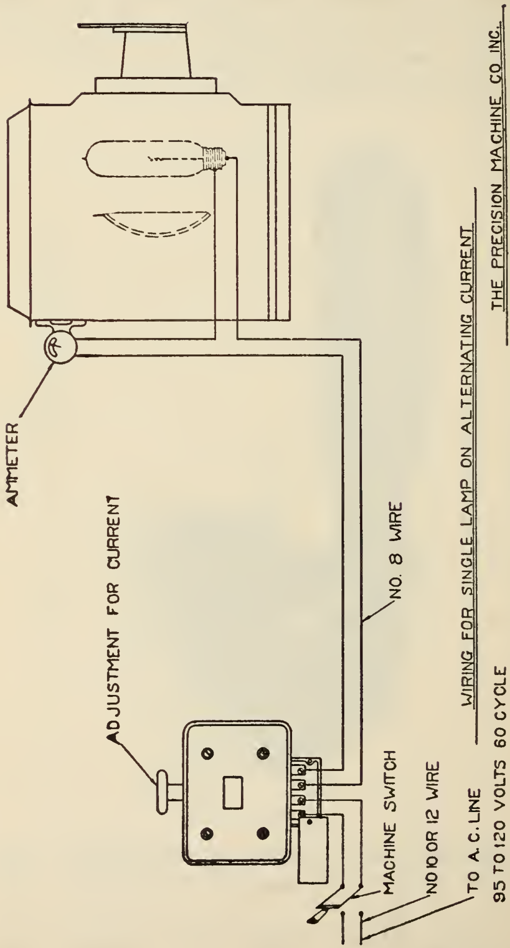

FIG. 190

Simplex Mazda Wiring Diagram

Now swing mirror to one side as far as possible by means of knob (C-1) and lock same into position by turning knob (D-1) to right. This throwing the mirror to one side is done in order to prevent mirror image from being confused with lamp filament, as will be described later.

FOCAL DISTANCES

Attention is now called to the Optical Diagram (page 492), which shows the approximate distances to be used as a basis of operation between the morror, the condensers and the cooling plate of the machine.

Should a quarter size (1¾″ diameter) projector lens be used it is now necessary to place ruler against the surface of the 7½-inch (front) condenser and move lamphouse slowly forward or backward until a distance of nine inches separates the front condenser surface from the film position or aperture plate on mechanism.

Should the half size (2⅝″ diameter) projector lens be used, this distance should be increased to eleven inches.

ADJUSTING LAMP

Turn knob (B—Fig. 186), which is used to carry lamp carriage forward and backward, until lamp filament (T—Fig. 187) is 3⅝ inches away from flat surface of 6½ (rear) condenser.

CONNECTING UP APPARATUS
(For alternating current)

We are now ready to connect the apparatus with regulator, as designated in diagram marked "A. C. Wiring Diagram" (page 494).

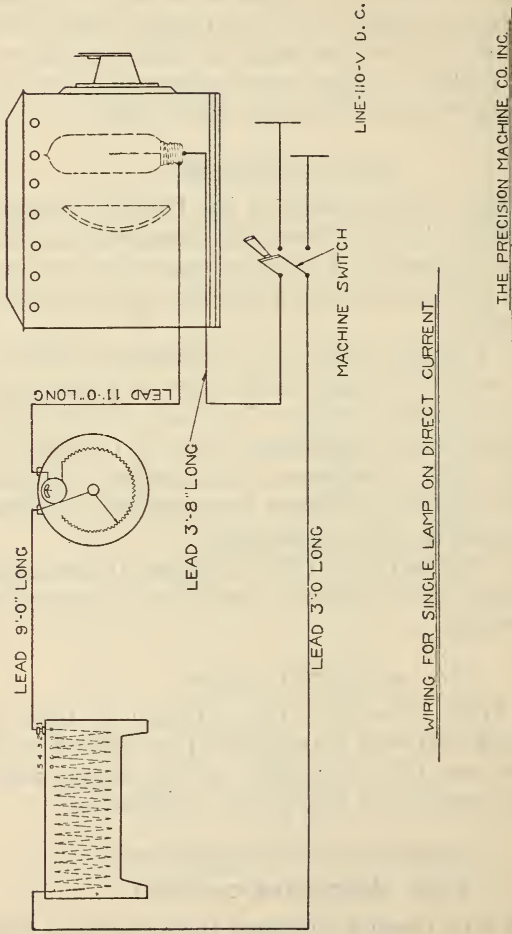

Fig. 191
Simplex Mazda Wiring Diagram

Note that this diagram is based on voltages ranging from 95 to 120 inclusive.

It will be noted that the ammeter for registering lamp amperage will be found packed separately in carton which comes in lamphouse shipping case.

This ammeter is to be attached to bracket on rear of lamphouse, as designated in A. C. Wiring diagram, by means of screws located in bracket.

Warning—In no case should ammeter be placed onto regulator, as it will not register properly in this location, owing to electrical disturbances.

Turn knob (B—Fig. 186) which is used to carry lamp carriage forward and backward until lamp filament (T—Fig. 187) is 3⅝ inches away from flat surface of 6½ (rear) condenser.

CONNECTING UP APPARATUS

(For direct current)

We are now ready to connect the apparatus with regulator as designated in diagram marked "Wiring for Single Lamp on Direct Current" (page 496).

Note that this diagram is based on voltages ranging from 95 to 120, inclusive.

It will be noted that there are two resistance units. One a fixed resistance or "cage type," the other a plate or dial type.

Attention is called herewith to the ammeter, which is mounted upon the latter dial resistance plate.

Turn regulator handle on dial to the right until it reaches the stop.

Now throw the machine switch in and out

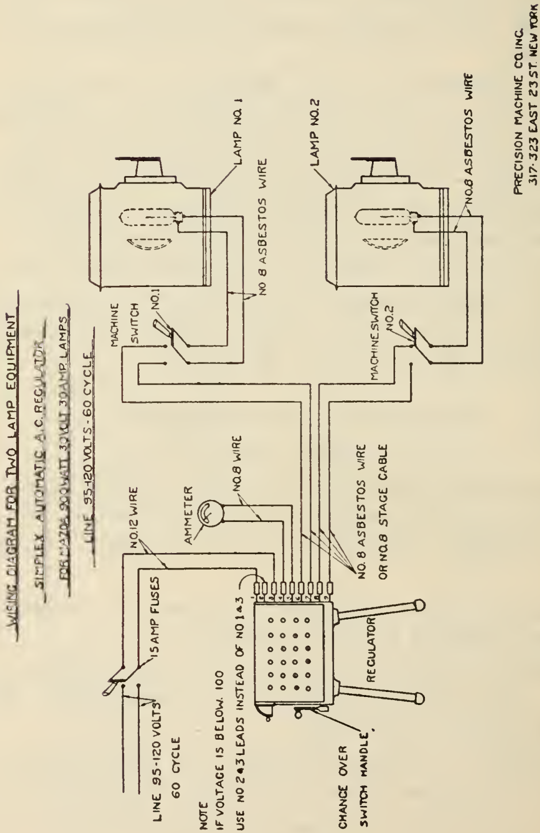

FIG. 192
Simplex Mazda Wiring Diagram

quickly, or "flash" it, watching ammeter carefully in order to determine whether it is registering forward or backward.

If ammeter registers backward, disconnect the two leads on the dial resistance and reverse them.

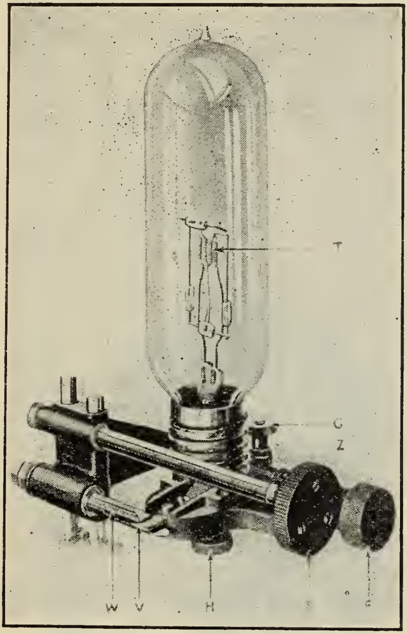

FIG. 193

This should have the effect of changing the polarity.

After again making the connections secure, repeat the "flash" on the machine switch in order to be assured of the correct polarity.

If polarity is correct, leave machine switch in. This will result in ammeter registering a reading

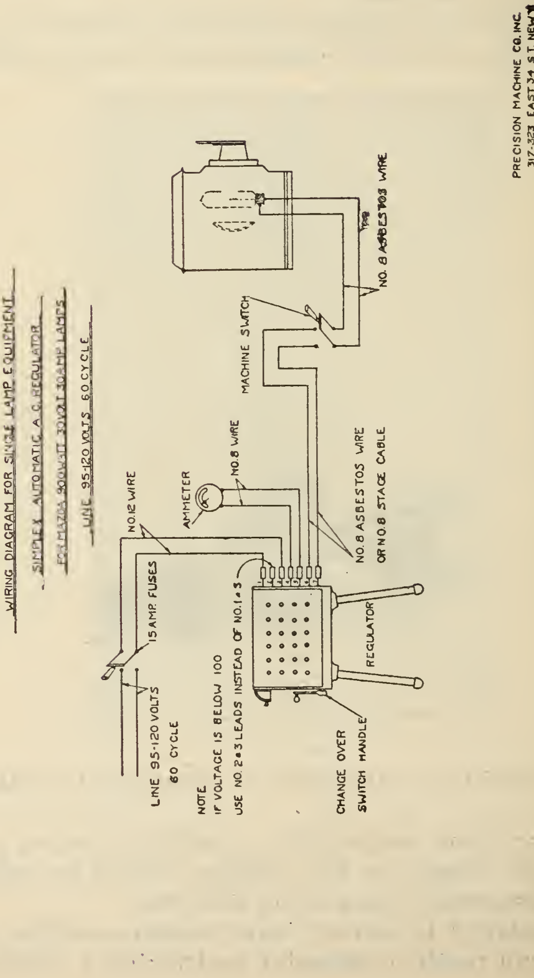
WIRING DIAGRAM FOR SINGLE LAMP EQUIPMENT
SIMPLEX AUTOMATIC A.C. REGULATOR
FOR MAZDA 900WATT 30VOLT 30AMP LAMPS
LINE 95-120 VOLTS 60 CYCLE
NO.12 WIRE
15 AMP. FUSES
AMMETER
NO.8 WIRE
MACHINE SWITCH
NO.8 ASBESTOS WIRE
NO.8 ASBESTOS WIRE
OR NO.8 STAGE CABLE
LINE 95-120 VOLTS
60 CYCLE
NOTE
IF VOLTAGE IS BELOW 100
USE NO. 2 & 3 LEADS INSTEAD OF NO. 1 & 3
REGULATOR
CHANGE OVER
SWITCH HANDLE
PRECISION MACHINE CO. INC.
317-323 EAST 34 ST. NEW

FIG. 194

of something over 35 amperes. This should cause no concern, as the amperage will drop to approximately 25 amperes within a moment or two.

Note:—The ammeter must be closely watched during the burning period of the lamp and must in no case exceed the lamp rating, which in indicated on metal base of lamp.

Now lift up fire shutter on mechanism and fasten same by inserting tooth-pick or match behind same in such a manner that fire shutter will remain open.

Now lift dowser on lamphouse hood; this will allow the light to be centered on fire shutter on mechanism as indicated in Fig. 196.

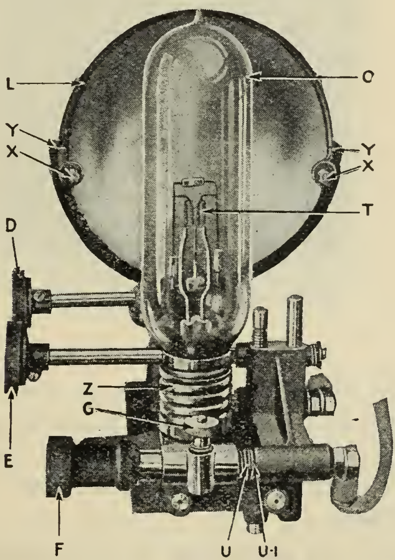

FIG. 195

FOCUSING LAMP

It is necessary that this circle of light shall cut all corners of cooling plate, as shown in Fig. 196.

Should the light circle be either too high or too low, adjustment for bringing it into true position is made by operating knob (E—Fig. 186) and watching results on cooling plate.

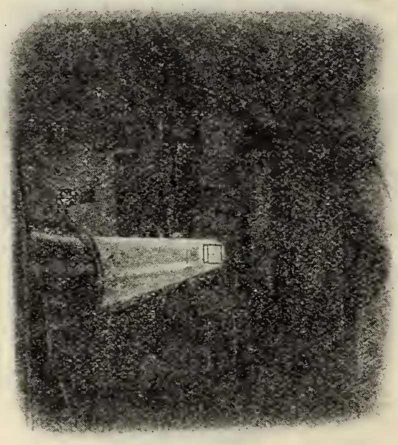

Fig. 196

Should circle of light be to one side, loosen thumb screw (G—Fig. 186), then turn knob (F—Fig. 186) forward or backward, as may be necessary, until circle of light is in true position on cooling plate.

Should it be necessary in this operation to adjust lamp to left, it is necessary to push firmly

against knob (F.1) in order to produce proper movement of lamp.

LOCKING LAMP

When this adjustment has been satisfactorily made, tighten thumb screw (G—Fig. 186) securely. This operation locks knob (F—Fig. 186), preventing lamp from loosely swinging should the lamp holder be taken out.

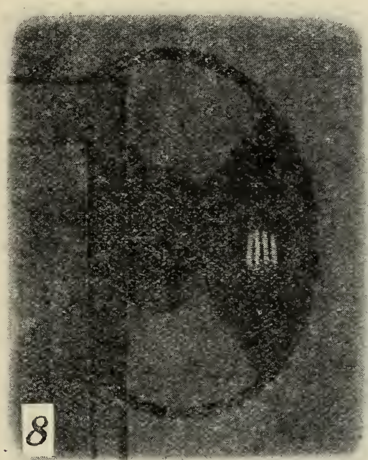

Fig. 197

FOCUSING LAMP FILAMENT ON CARD OR SHUTTER

Now it is necessary that the lamp filament be focused.

We now remove the projector lens from mechanism and move revolving shutter out on shutter shaft until a distance of 10¼ inches separates

the cut-off blade on shutter from the aperture plate or film position on mechanism.

Should it not be convenient to use revolving shutter for this purpose, a card may be placed in the same position, making sure, however, that the distance of 10¼ inches is maintained.

We now have an image of the lamp filament outlined on the shutter blade or card, as indicated in Fig. 197. If image is not in exact focus, check up carefully all measurements. If measurements are all correct, it is now necessary to sharpen up or focus filament by turning knob (B—Fig. 186) either to right or left until the filament is clearly outlined upon card or shutter blade.

RESULTS ON FOCUSING CARD OR SHUTTER

Now unlock mirror by turning knob (D-1) to left and swing mirror over by means of knob (C-1).

We now see besides the lamp filament on the card or shutter another image; this is much fainter in definition than the lamp filament. This faint image is called the mirror image.

It is now necessary to sharpen this up as much as possible; this is done by adjusting mirror (L-1), turning knob (A-1) forward or back until clear definition is obtained.

It is now necessary to center mirror image in same position as the filament image.

By swinging knob (C-1) to right will register mirror to left, and vice-versa.

Should mirror filament register too high or too low, immediate true position may be obtained by turning knob (C-1) to right or left.

MERGING BOTH FILAMENTS

Now that both filaments show up sharp and are both in relative position, swing mirror over by means of knob (C-1) ; this will move mirror image over on card or shutter, the purpose being to register the mirror image filament in between the open spaces of the lamp filament, as shown in Fig. 9.

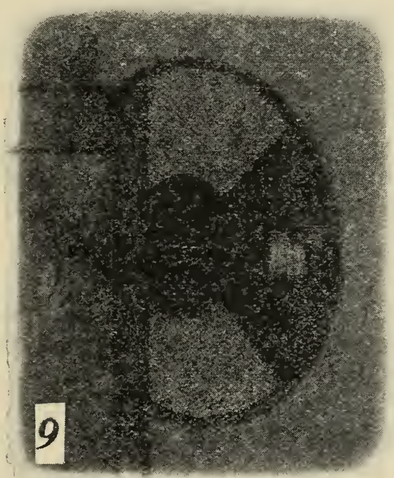

FIG. 198

LOCKING MIRROR

Now make sure that the results on card or shutter are all that should be desired, and lock mirror into position by turning knob (D—Fig. 186) to right.

INCREASED AMPERAGE
(Direct current)

After the lamp and resistance have become sufficiently warmed up, turn the dial handle slowly to the left, carefully watching the ammeter until the indicator of same registers 30 amperes.

INCREASING AMPERAGE
(Alternating current)

Now bring lamp up to full capacity of 30 amperes by turning regulator handle to right, while carefully watching ammeter until same registers at 30 amperes.

Warning—Do not under any circumstances exceed 30 amperes, as by so doing will result in the overloading and subsequent damage to lamps.

CLEAR FIELD OF LIGHT

We now have the lamp at full amperage.

Replace projector lens into mechanism.

Focus same up sharply.

Screen should now show a clean, evenly distributed field of light.

Should any discoloration or shadows be apparent on screen, slide lamphouse carefully and slowly backward or forward until discoloration disappears.

When screen is all cleared up through the foregoing operation, fasten lamphouse by tightening up wing screw (R—Fig. 186).

Now take away focusing card and readjust shutter (if necessary), and the equipment is ready for operation.

ADJUSTING EXTRA LAMP

In order to be prepared for any emergency, it is wise to have an extra lamp and holder all ready for instant use.

Follow instructions for setting lamp into holder, as already described, and set to one side where it will be quickly available.

Should same be required while machine is in operation, pull machine switch, throw back regulator handle to "low" and withdraw burned out or defective lamp and insert new lamp and holder as already described.

CAUTION—MAKE SURE THAT MACHINE SWITCH IS OFF BEFORE WITHDRAWING OLD LAMP.

Now throw in machine switch and bring regulator up to 30 amperes.

Now center spot light on cooling plate, as before described, and get as clear a field as possible until an opportunity of procuring permanent readjustment is available.

PLATE 1

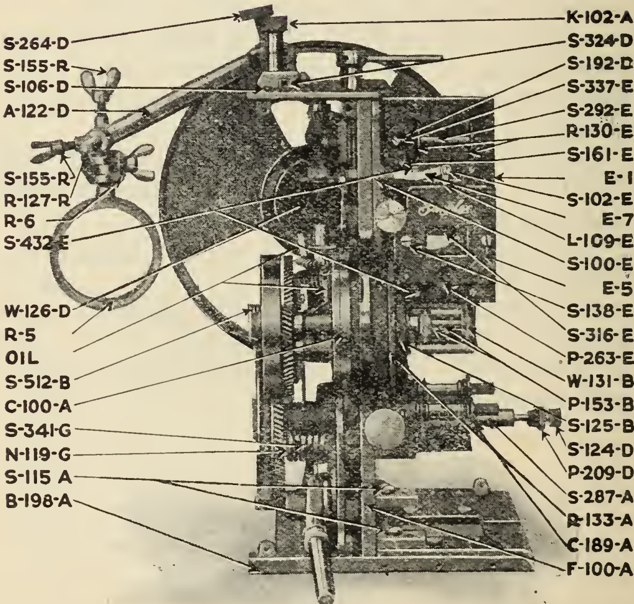

FIG. 199

SIMPLEX PARTS
(HEAD)

Name

S-264-D —Stereo Lens Adjusting Screw.
S-155-R —Stereo Universal Clamp Wing Screw.
S-106-D —Stereo Slide Stop Screw.
A-122-D —Stereo Arm.
S-155-R —Stereo Universal Clamp Wing Screw.
R-127-R —Stereo Lens Adjusting Rod.
R-6 —Stereo Lens Holder Universal Clamp.
S-432-E —Film Trap Shoe Screw.
W-126-D —Governor Weight.
R-5 —Stereo Lens Holder.
S-512-B —Fly Wheel Set Screw.
C-100-A —Framing Cam.
S-341-G —Picture Framing Handle Friction Spring.
N-119-G —Picture Framing Lever Pivot Screw Nut.
S-115-A —Center Frame Screw.
B-198-A —Mechanism Base.
K-102-A —Focusing Pinion Knob.
S-324-D —Stereo Slide.
S-192-D —Film Shutter Screw.
S-337-E —Lateral Guide Roller Spring.
S-292-E —Lateral Guide Roller Shaft.
R-130-E —Lateral Guide Roller.
S-161-E —Auto, Fire Shutter Stop Screw.
E-1 —Film Trap Complete.
S-102-E —Auto. Fire Shutter Link Retain Screw.
E-7 —Auto. Fire Shutter Lift Lever.
L-109-E —Auto. Fire Shutter Lift Link.
S-100-E —Auto. Fire Shutter Lever Screw.
E-5 —Film Heat Shield Complete.
S-138-E —Film Trap Heat Shield Retain Screw.
S-316-E —Auto. Fire Shutter.
P-263-E —Right Back Over Latch Plate.
W-131-B —Intermittent Sprocket.
P-153-B —Intermittent Sprocket Taper Pin.
S-125-B —Eccentric Bushing Screw.
S-124-D —Driving Arm Retain Screw.
P-209-D —Driving Arm Retain Plug.
S-287-A —Handle Shaft.
R-133-A —Framing Cam Adjusting Ring.
C-189-A —Handle Shaft Driving Collar.
F-100-A —Centre Frame.

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PLATE 2

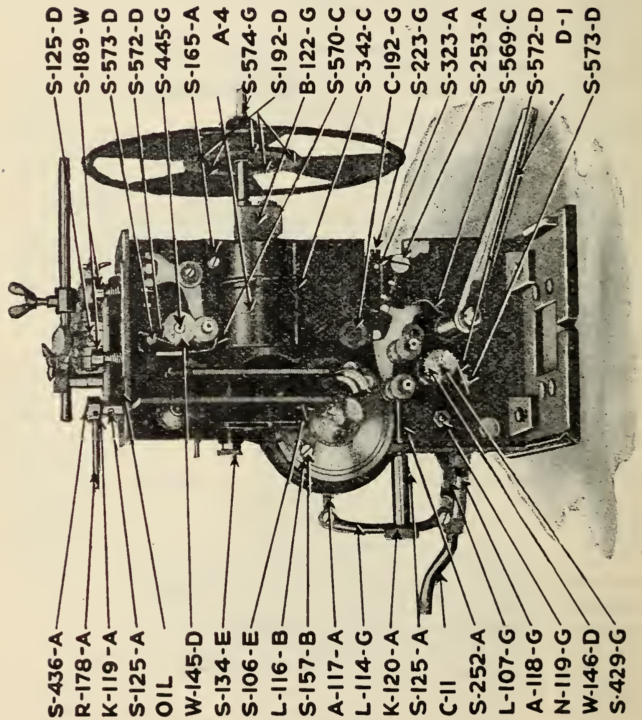

FIG. 200

SIMPLEX PARTS
(HEAD)

	Name
S-436-A	—Focusing Knob Set Screw.
R-178-A	—Focusing Knob Rod.
K-119-A	—Focusing Pinion Rod Knob.
S-125-A	—Eccentric Bushing Screw.
W-145-D	—Upper Feed Sprocket.
S-134-E	—Film Trap Door Stud Screw.
S-106-E	—Right Back Cover Latch Plate Screws.
L-116-B	—Intermittent Case Cover Lock.
S-157-B	—Intermittent Case Cover Lock Screw.
A-117-A	—Picture Framing Arm.
L-114-G	—Picture Framing Connecting Link.
K-120-A	—Shutter Adjusting Screw Knob.
S-125-A	—Shutter Adjusting Screw Knob Set Screw.
C-11	—Framing Handle Complete.
A-252-A	—Shutter Adjusting Screw.
L-107-G	—Picture Framing Lever.
A-118-G	—Picture Framing Handle Arm.
N-119-G	—Picture Framing Lever Pivot Screw Nut.
W-146-D	—Lower Feed Sprocket.
S-429-G	—Lower Sprocket Shaft.
S-125-D	—Eccentric Bushing Screw.
S-189-W	—Magazine Bracket Screw.
S-573-D	—Upper and Lower Stripper Studs.
S-572-D	—Upper and Lower Stripper.
S-445-G	—Upper Sprocket Shaft.
S-165-A	—Pad Roller Arm Washer Screw.
A-4	—Projecting Lens Holder and Slide.
S-574-G	—Shutter Shaft.
S-192-D	—Shutter Spider Screws.
B-122-G	—Shutter Gear Bracket.
S-570-C	—Upper Pad Roller Arm Spring.
S-342-C	—Projecting Lens Holder Slide Rod Spring.
C-192-G	—Intermediate Shaft Retaining Collar.
S-223-G	—Framing Slide Lever Stud Set Screw.
S-323-A	—Shutter Adjusting Slide.
S-253-A	—Shutter Adjusting Slide Set Screw.
S-569-C	—Lower Pad Roller Arm Spring.
S-572-D	—Upper and Lower Stripper.
D-1	—Driving Handle Complete.
S-573-D	—Upper and Lower Stripper Stud.

PLATE 3

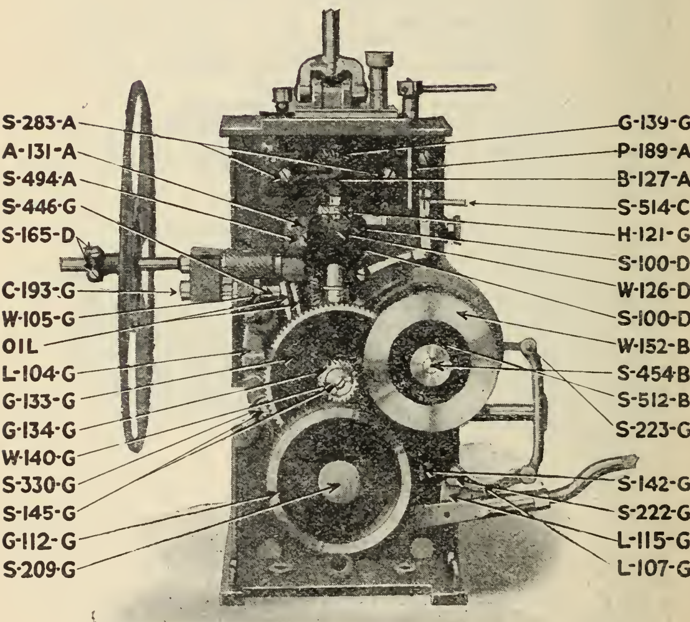

FIG. 201

SIMPLEX PARTS

(HEAD)

Name

S-283-A —Vertical Shaft Bracket Screw.
A-131-A —Focusing Rack Arm.
S-494-A —Focusing Rack Retain Screw.
S-446-G —Spiral Driving Gear Shaft.
S-165-D —Shutter Spider Collar Screw.
C-193-G —Spiral Driving Gear Shaft Collar.
W-105-G —Spiral Drive Gear Shaft Washer.
L-104-G —Framing Slide Lever.
G-133-G —Intermediate Gear No. 2.
G-134-G —Intermediate Gear No. 1.
W-140-G —Intermediate Gear Retain Washer.
S-330-G —Framing Slide Lever Spring.
S-145-G —Intermediate Gear Washer Retain Screw.
G-112-G —Main Driving Gear.
S-209-G —Main Driving Gear Retain Screw.
G-139-G —Upper Sprocket Shaft Gear.
P-189-A —Focusing Pinion.
B-127-A —Vertical Shaft Bracket.
S-514-C —Fire Shutter Lifting Stud.
H-121-G —Governor Upper Link Holder.
S-100-D —Auto. Fire Shutter Lever Screw.
W-126-D —Governor Weight.
S-100-D —Governor Weight Screw.
W-152-B —Fly Wheel.
S-454-B —Fly Wheel Shaft.
S-512-B —Fly Wheel Set Screw.
S-223-G —Picture Framing Connecting Link Screw.
S-142-G —Picture Framing Lever Pivot Screw.
S-222-G —Picture Framing Link Screw.
L-115-G —Picture Framing Link.
L-107-G —Picture Framing Lever.

PLATE 4

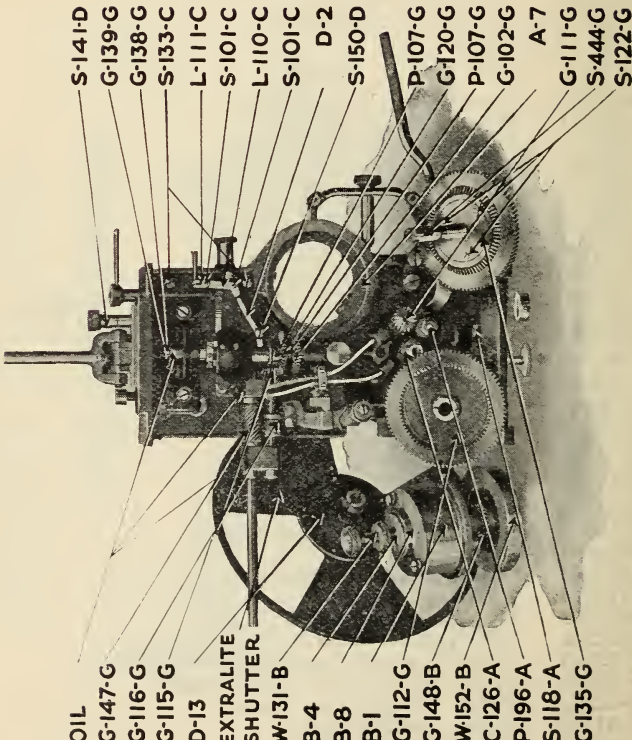

FIG. 202

SIMPLEX PARTS

(HEAD)

Name

G-147-G —Spiral Gear.
G-116-G —Spiral Gear with Broached Hole.
G-115-G —Shutter Drive Bevel Gear.
D-13 —Shutter Spider Complete.
Extralite Shutter.
W-131-B —Intermittent Sprocket.
B-4 —Eccentric Bushing and Sleeve.
B-8 —Intermittent Case Cover.
B-1 —Intermittent Case.
G-112-G —Main Driving Gear.
G-148-B —Fly Wheel Gear.
W-152-B —Fly Wheel.
C-126-A —Main Driving Gear Clutch.
P-196-A —Picture Framing Handle Pivot.
S-118-A —Motor Drive Pinion Set Screw.
G-135-G —Intermediate Bevel Gear.
S-141-D —Stereo Focusing Knob Set Screw.
G-139-G —Upper Sprocket Shaft Gear.
G-138-G —Bevel Gear No. 3.
S-133-C —Film Trap Screw.
L-111-C —Governor Lift Lever Connecting Link.
S-101-C —Auto Fire Shutter Hinge Screw.
L-110-C —Governor Lift Lever Link.
S-101-C —Auto Fire Shutter Hinge Screw.
D-2 —Governor Lift Lever Roller Complete.
S-150-D —Governor Lift Lever Pivot Screw.
P-107-G —Vertical Shaft Gear Taper Pin.
G-120-G —Vertical Shaft Gear.
P-107-G —Vertical Shaft Gear Taper Pin.
G-102-G —Bevel Gear No. 2.
A-7 —Framing Cam and Arm.
G-111-G —Lower Sprocket Gear.
S-444-G —Intermediate Shaft.
S-122-G —Intermediate Bevel Gear Fastening Screw.

PLATE 5

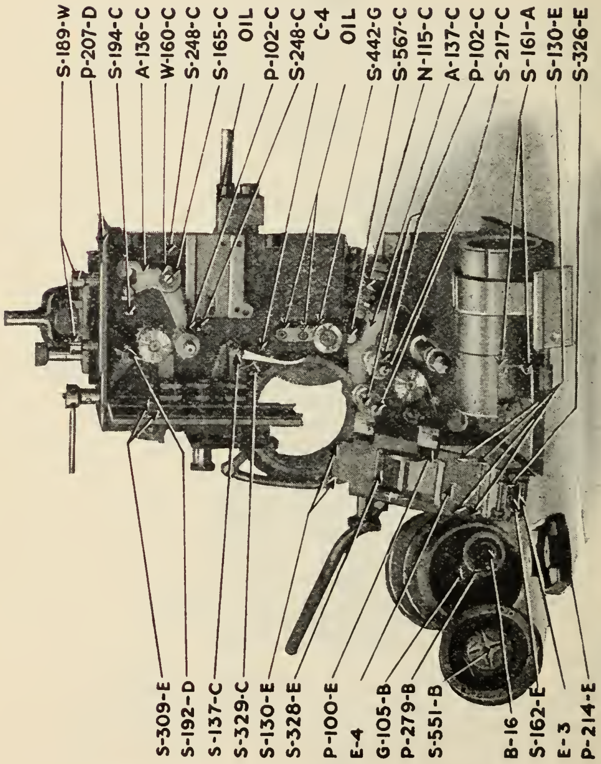

FIG. 203

SIMPLEX PARTS

(HEAD)

Name

S-309-E —Film Trap Shoe.
S-192-D —Upper and Lower Left Door Hinge Screw.
S-137-C —Film Trap Door Trip Lever Screw.
S-329-C —Trip Lever Spring.
S-130-E —Film Guide Holder Screw.
S-328-E —Film Trap Door Pad Spring.
P-100 E. —Film Trap Door Pad.
E-4 —Film Trap Door Complete.
G-105-B —Fly Wheel Shaft Gear.
P-279-B —Star Wheel Cam Pin.
S-551-B —Star Wheel and Shaft.
B-16 Star Wheel Cam Complete.
S-162-E —Film Guide Retain Spring Screw.
E-3 —Intermittent Film Guide.
P-214-E —Film Projector.
S-189-W —Magazine Bracket Screw.
P-207-D —Top Plate.
S-194-C —Sprocket Roller Arm Screw.
A-136-C —Upper Pad Roller Arm.
W-160-C —Upper Pad Roller Arm Washer.
S-248-C —Roller Holder Screw.
S-165-C —Pad Roller Arm Washer Screw.
P-102-C —Pad Roller.
S-248-C —Upper Magazine Roller Holder Screw
C-4 —Film Trap Trip Lever.
S-442-G —Intermediate Shaft Collar Set Screw.
S-567-C —Pad Roller Arm Stud.
N-115-C —Sprocket Roller Arm Nut.
A-137-C —Lower Pad Roller Arm.
P-102-C —Pad Roller.
S-217-C —Pad Roller Screw.
S-161-A —Projecting Lends Holder Screw.
S-130-E —Film Guide Holder Screws.
S-326-E —Film Guide Retain Spring.

PLATE 6

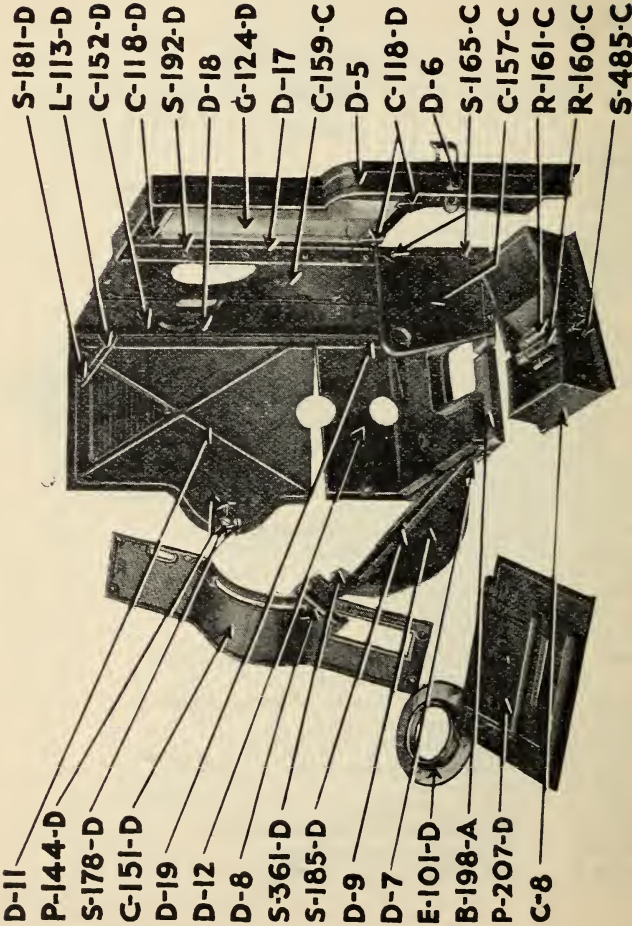

FIG. 204

SIMPLEX PARTS

(HEAD)

Name

D-11 —Left Door and Knob Complete.
P-144-D —Left Door Lock Pin.
S-178-D —Left Door Knob Screw.
C-151-D —Left Back Cover.
D-19 —Lower Left Door Hinge.
D-12 —Lower Left Door Complete.
D-8 —Right Back Cover Latch Knob Complete.
S-361-D —Intermittent Sprocket Stripper.
S-185-D —Lock Stop Screw.
D-9 —Right Back Cover Complete.
D-7 —Right Back Cover Hinge Complete.
E-101-D —Medium Size Escutcheon.
B-198-A —Mechanism Base.
P-207-D —Top Plate.
C-8 —Upper Magazine Roller Holder Complete.
S-181-D —Left Door Stop Link Screw.
L-113-D —Left Door Stop Link.
C-152-D —Left Front Cover.
C-118-D —Bevel Glass Clamp.
S-192-D —Right and Left Door Hinge Screw.
D-18 —Upper Left Door Hinge.
G-124-D —Right Door Glass.
D-17 —Right Door Hinge.
C-159-C —Right Front Cover.
D-5 —Right Door and Knob Complete.
C-118-D —Bevel Glass Clamp.
D-6 —Right Door Lock Spring and Button.
S-165-C —Cover Screw.
C-157-C —Right Cover.
R-161-C —Large Magazine Roller.
R-160-C —Small Magazine Roller.
S-485-C —Magazine Roller Screw.

PLATE 10

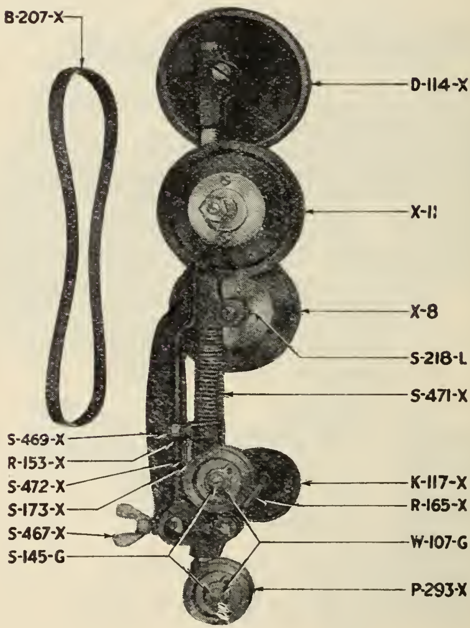

FIG. 205

SIMPLEX PARTS
(SPEED REGULATOR)

	Name
B-207-X	—Speed Control Belt.
S-469-X	—Tension Pulley Carrier Roller Screw.
R-153-X	—Tension Pulley Carrier Roller.
S-472-X	—Square Rod Friction Spring.
S-173-X	—Friction Spring Screw.
S-467-X	—Main Frame Clamp Screw.
S-145-G	—Pulley Carrier Screw.
D-114-X	—Starting Mechanism Friction Disc.
X-11	—Speed Control Main Pulley and Oil Cup.
X-8	—Speed Control Friction Disc.
S-218-L	—Set Screw.
S-471-X	—Belt Tension Spring.
K-117-X	—Speed Control Knob.
R-165-X	—Speed Adjusting Knob Rod.
W-107-G	—Pulley Washer.
P-293-X	—Deflecting Pulley.

PLATE 11

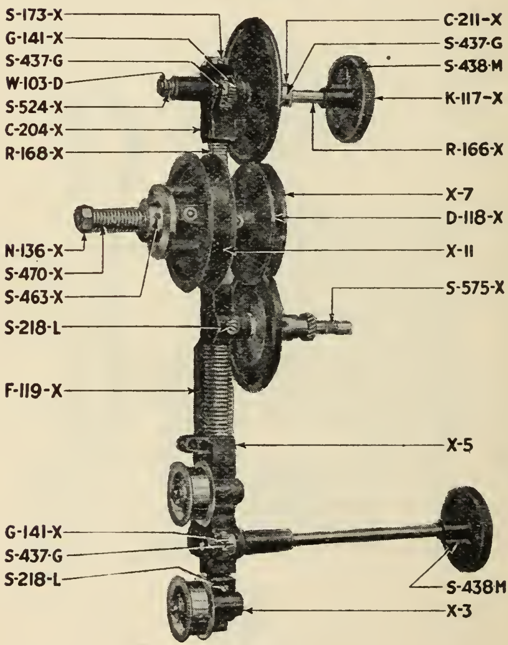

FIG. 206

SIMPLEX PARTS

(SPEED REGULATOR)

Name

S-173-X —Friction Disc Carrier Stop Screw.
G-141-X —Speed Adjusting Gear.
S-437-G —Collar Set Screw.
W-103-D —Starting Rod Friction Spring Retaining Washer.
S-524-X —Starting Rod Fricton Spring.
C-204-X —Starting Mechanism Friction Disc Carrier.
R-168-X —Square Rod for Horizontal Handle.
N-136-X —Friction Spring Nut.
S-470-X —Friction Spring.
S-463-X —Internal Friction Disc Driving Flange Set Screw.
S-218-L —Set Screw.
F-119-X —Speed Control Main Frame.
G-141-X —Speed Adjusting Gear.
S-437-G —Gear Set Screw.
S-218-L —Carrier Set Screw.
C-211-X —Starting Knob Rod Collar.
S-437-G —Gear Set Screw.
S-438-M —Starting Knob Set Screw.
K-117-X —Speed Control Knob.
R-166-S —Starting Knob Rod.
X-7 —External Friction Disc Complete.
D-118-X —Internal Friction Disc.
X-11 —Speed Control Main Pulley and Oil Cup.
S-575-X —Speed Control Motor Pinion Stud.
X-5 —Tension Pulley Carrier Complete.
S-438-M —Speed Control Knob Set Screw.
X-3 —Idler Pulley Carrier Complete.

PLATE 13

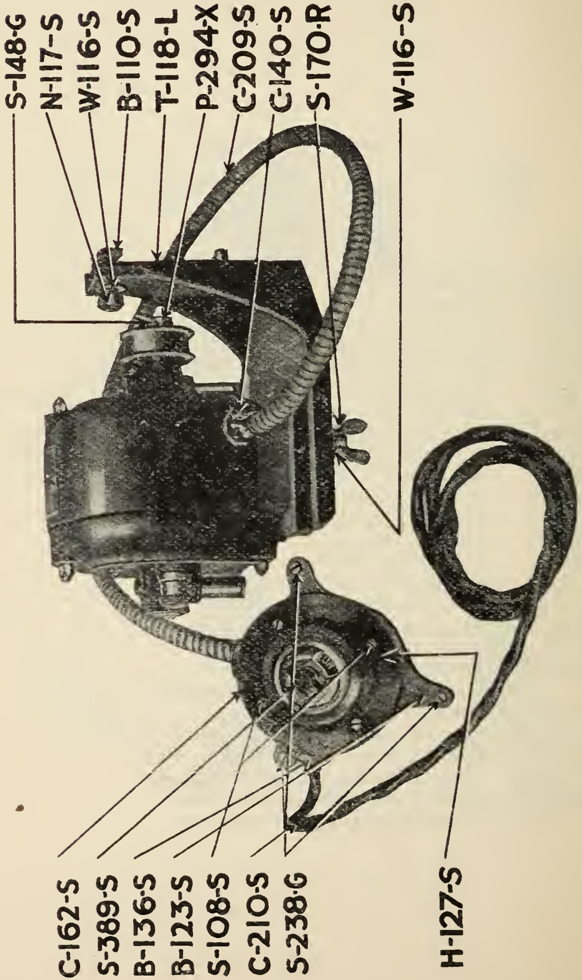

FIG. 208

SIMPLEX PARTS
(MOTOR)

Name

C-162-S —Outlet Box Cover with Switch Bridge.
S-389-S —Snap Switch.
B-136-S —½" T. & B. Bushing.
B-123-S —Snap Switch Bracket.
S-108-S —Binding Post Cover Fastening Screw.
C-210-S —Canvasite Cord.
S-238-G —Switch Box Bracket Fastening Screw.
H-127-S —Snap Switch Holder.
S-148-G —Motor Pulley Screw.
N-117-S —Motor Table Attachment Bolt Nut.
W-116-S —Motor Table Attachment Bolt Washer.
B-110-S —Motor Table Attachment Bolt.
T-118-L —Motor Table.
P-294-X —Motor Pulley.
C-209-S —Armored Cable.
C-140-S —⅜" Squeeze Connectors.
S-170-R —Motor Fastening Screw.

PLATE 14

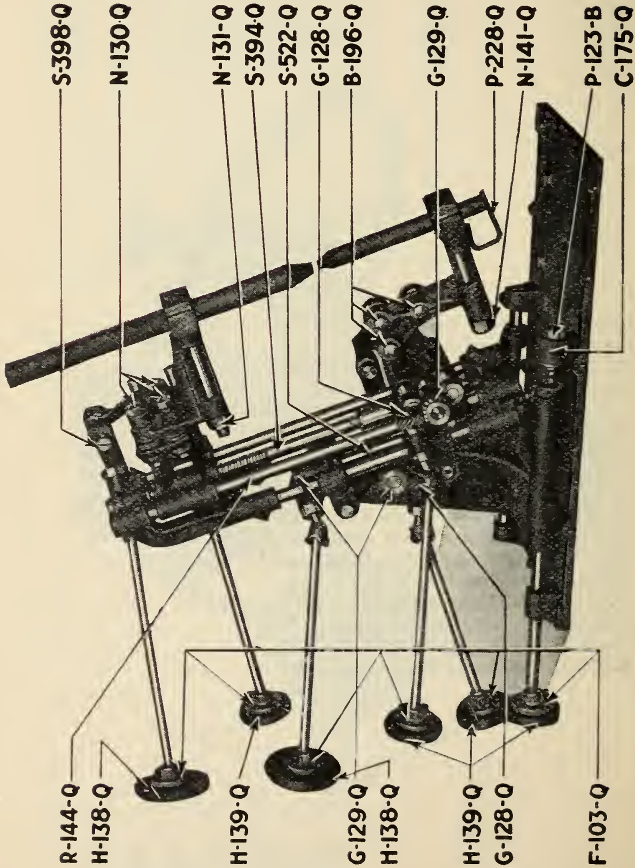

FIG. 209

SIMPLEX PARTS

(ARC LAMP)

	Name
R-144-Q	—Upper and Lower Carbon Frame Guide Rod.
H-138-Q	—Large Fibre Handle.
H-139-Q	—Small Fibre Handle.
G-129-Q	—Spiral Gear for ½″ Shaft.
G-128-Q	—Spiral Gear for ⅜″ Shaft.
F-103-Q	—Handle Flange.
S-398-Q	—Contact Piece Connection Screw.
N-130-Q	—Upper Carbon Contact Piece Retain Nut.
N-131-Q	—Upper Carbon Clamp Nut.
S-394-Q	—Carbon Feed Screw.
S-522-Q	—Vertical Adjustment of Arc Screw.
G-128-Q	—Spiral Gear for ⅜″ Shaft.
B-196-Q	—Carbon Jaw Bolt.
G-129-Q	—Spiral Gear for ½″ Shaft.
P-228-Q	—Lower Carbon Stop Pin.
N-141-Q	—Lower Carbon Clamp Nut.
P-123-B	—Taper Pin.
C-175-Q	—Collar for ⅜″ Shaft.

PLATE 15

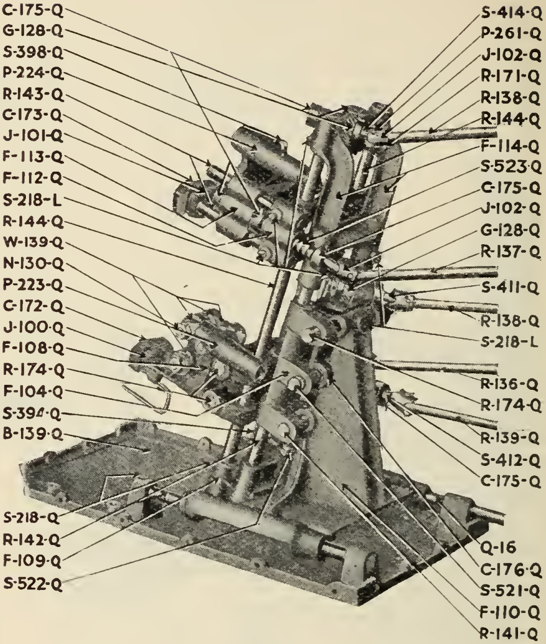

FIG. 210

SIMPLEX PARTS

Name

C-175-Q —Collar for 3/8″ Shaft.
G-128-Q —Spiral Gear for 3/8″ Shaft.
S-398-Q —Contact Piece Connection Screw.
P-224-Q —Contact Piece for Top Carbon.
R-143-Q —Upper Carbon Secondary Guide Rod.
C-173-Q —Upper Carbon Clamp.
J-101-Q —Upper Carbon Jaw.
F-113-Q —Upper Carbon Secondary Sliding Frame.

SIMPLEX PARTS

(HEAD)

Name

F-112-Q —Upper Carbon Main Sliding Frame.
R-144-Q —Upper and Lower Carbon Frame Guide Rod.
W-139-Q —Insulating Washer.
N-130-Q —Upper Carbon Contact Piece Retain Nut.
P-223-Q —Contact Piece for Lower Carbon.
C-172-Q —Lower Carbon Clamp.
J-100-Q —Lower Carbon Jaw.
F-108-Q —Lower Carbon Secondary Sliding Frame.
R-174-Q —Lower Carbon Cross Feed Sliding Rod.
F-104-Q —Burner Cross Feed Sliding Frame.
S-394-Q —Carbon Feed Screw.
B-139-Q —Burner Base.
S-218-Q —Headless Set Screw.
R-142-Q —Main Sliding Frame Guide Rod.
F-109-Q —Lower Frame Casting of 3rd Sliding Frame.
S-522-Q —Screw for Vertical Adjustment of Arc.
S-414-Q —Driving Shaft in Top Frame.
P-261-Q —Universal Joint Cotter Pin.
J-102-Q —Universal Joint.
R-171-Q —Universal Joint Rivet.
R-138-Q —Handle Rod, 10″.
R-144-Q —Upper and Lower Carbon Frame Guide Rod.
F-114-Q —Top Frame Casting of 3rd Sliding Frame.
S-523-Q —Screw for Top Carbon Longitudinal Adjustment.
C-175-Q —Screw for Top Carbon Longitudinal Adjustment.
C-175-Q —Collar for ⅜″ Shaft.
J-102-Q —Universal Joint.
G-128-Q —Spiral Gear for ⅜″ Shaft.
R-137-Q —Handle Rod, 9″.
S-411-Q —Driving Shaft in Lower Carbon Frame.
R-138-Q —Handle Rod, 10″.
S-218-L —Set Screw.
R-136-Q —Handle Rod, 8″.
R-174-Q —Lower Carbon Cross Feed Sliding Rod.
R-139-Q —Handle Rod, 10½″.
S-412-Q —Driving Shaft in Lower Carbon Frame.
C-175-Q —Collar for ⅜″ Shaft.
Q-16 —Horizontal Longitudinal Adjustment of Arc Screw.
C-176-Q —Collar for ½″ Shaft.
S-521-Q —Screw for Crosswise Adjustment of Arc.
F-110-Q —Main Sliding Frame.
R-141-Q —Main Cross Feed Sliding Rod.

PLATE 17

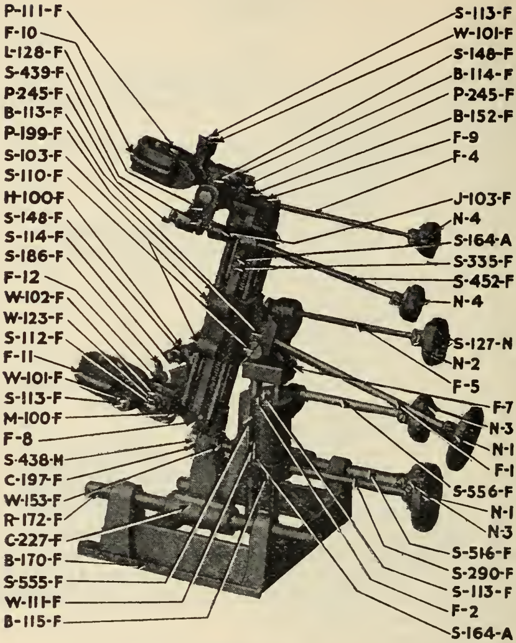

FIG. 211

SIMPLEX PARTS

Name

S-113-F —Carbon Holder Clamp Screw.
W-101-F —Carbon Holder Washer.
S-148-F —Set Screw.
B-114-F —Carbon Holder Bracket.
P-245-F —Upper Carbon Tilt Screw Cotter Pin.
B-152-F —Upper Carbon Feed Rack (Sub-Bracket).
F-9 —Upper Carbon Feed Rack Support.
F-4 —Upper Carbon Feed Rack Bracket Adjusting Screw.
J-103-F —Upper Carbon Tilt Screw Universal Joint.
N-4 —Feed Knob.
S-164-A —Tension Spring Screw.
S-335-F —Lamp Adjusting Gear Friction Spring.

SIMPLEX PARTS

	Name
S-452-F	—Upper Carbon Tilt Screw Adjusting Shaft.
N-4	—Feed Knob.
S-127-N	—Feed Knob Hub Screw.
N-2	—Carbon Feed Bracket Tilt Screw Knob.
F-5	—Carbon Feed Bracket Tilt Screw.
F-7	—Carbon Feed Bracket Support
N-3	—Feed Knob.
N-1	—Feed Knob.
F-1	—Carbon Feed Gear and Shaft.
S-556-F	—Lamp Lateral Screw Shaft.
N-1	—Feed Knob.
N-3	—Feed Knob.
S-516-F	—Lamp Carriage Screw.
S-290-F	—Lamp Adjusting Gear Shaft.
S-113-F	—Carbon Holder Clamp Screw.
F-2	—Lamp Adjusting Bracket Plate and Pins.
S-164-A	—Lamp Adjusting Friction Spring Screw.
P-111-F	—Carbon Holder Pin.
F-10	—Upper Carbon Holder.
L-128-F	—Carbon Jaw Tilt Screw Lever.
S-439-F	—Upper Carbon Jaw Tilt Screw.
P-245-F	—Upper Carbon Tilt Screw Cotter Pin.
B-113-F	—Carbon Feed Bracket.
P-199-F	—Carbon Feed Bracket Plate.
S-103-F	—Carbon Feed Bracket Plate Screw.
S-110-F	—Carbon Feed Bracket Support Screw.
H-100-F	—Carbon Jaw Tilt Screw Handle.
S-148-F	—Set Screw.
S-114-F	—Carbon Jaw Tilt Screw.
S-186-F	—Lower Carbon Holder Wing Screw.
F-12	—Carbon Holder Bracket.
W-102-F	—Carbon Holder Mica Washer.
W-123-F	—Upper Carbon Feed Rack Sub-Bracket Washer.
S-112-F	—Carbon Holder Bracket Screw.
F-11	—Lower Carbon Holder.
W-101-F	—Carbon Holder-Washer.
S-113-F	—Carbon Holder Clamp Screw.
M-100-F	—Carbon Holder Sheet Mica.
F-8	—Lower Carbon Feed Rack Bracket.
S-438-M	—Set Screw.
C-197-F	—Lamp Carriage Screw Collar.
W-153-F	—Lamp Carriage Screw Washer.
R-172-F	—Lamp Carriage Guide Rod.
C-227-F	—Lamp Carriage.
B-170-F	—Burner Support Bracket.
S-555-F	—Lamp Adjusting Plate Tension Spring.
W-111-F	—Lamp Adjusting Plate Washer.
B-115-F	—Lamp Adjusting Bracket.

PLATE 18

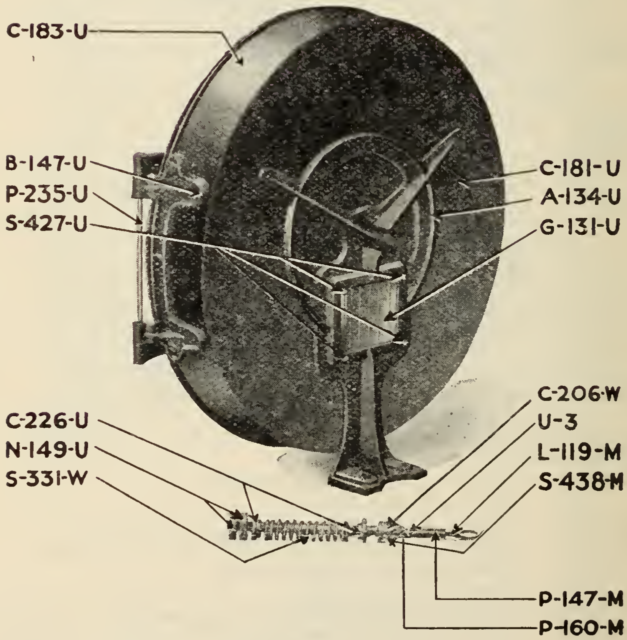

FIG. 212

SIMPLEX PARTS

(MAGAZINE)

	Name
C-183-U	—Upper Magazine Cover.
B-147-U	—Magazine Hinge Bracket.
P-235-U	—Magazine Hinge Pin.
S-427-U	—Magazine Wire Glass Retaining Plate Screw.
C-226-U	—Friction Adjusting Spring Collar.
N-149-U	—Friction Adjusting Spring Nut.
S-331-W	—Friction Adjusting Spring.
C-181-U	—Upper Magazine Case, 16″.
A-134-U	—Upper Magazine Arm, 16″.
G-131-U	—Upper Magazine Door Wire Glass.
C-206-W	—Upper Magazine Collar.
U-3	—Upper Take-Up Shaft.
L-119-M	—Reel Lock.
S-438-M	—Magazine Collar Set Screw.
P-147-M	—Reel Lock Pin.
P-160-M	—Reel Shaft Collar Pin.

PLATE 19

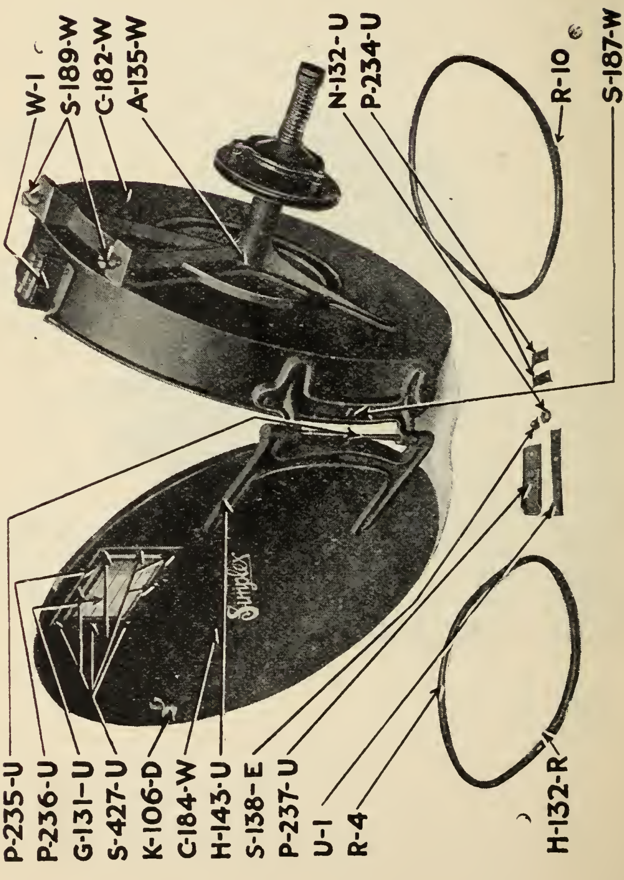

FIG. 213

SIMPLEX PARTS

(MAGAZINE)

P-235-U —Magazine Hinge Pin.
P-236-U —Magazine Wire Glass Retaining Plate.
G-131-U —Lower Magazine Door Wire Glass.
S-427-U —Magazine Wire Glass Retaining Plate Screw.
N-135-U —Magazine Wire Glass Retainer Plate Nut.
K-106-D —Lower Magazine Door Knob.
C-148-W —Lower Magazine Cover, 16″.
H-143-U —Magazine Hinge.
S-138-E —Magazine Latch Spring Retain Screw.
P-237-U —Magazine Latch Spring Protector.
U-1 —Magazine Latch.
R-4 —Take-Up Belt for Reels with Small Hubs.
H-132-R —Belt Hook.
W-1 —Lower Magazine Roller Holder.
S-189-W —Magazine Arm Screw.
C-182-W —Lower Magazine, 16″.
A-135-W —Lower Magazine Arm, 16″.
N-132-U —Magazine Latch Spring Retaining Nut.
P-234-U —Magazine Latch Spring Distance Piece.
R-10 —Take-Up Friction Belt for Reels with Large Hubs.
S-187-W —Lower Magazine Hinge Screw.

PLATE 20

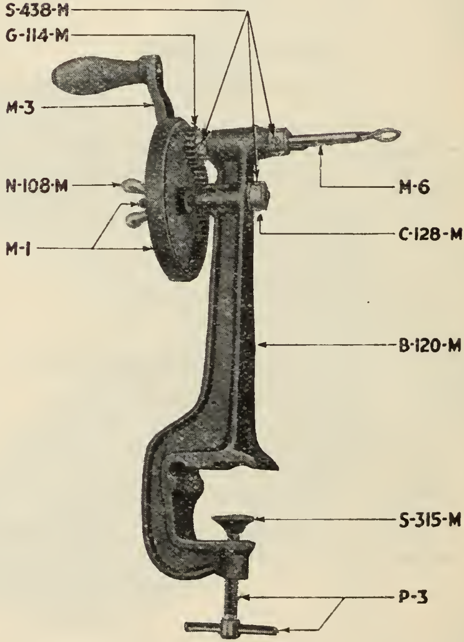

FIG. 214

SIMPLEX PARTS

(REWINDER)

Ncme

"M"	—Rewinder Bracket Complete.
S-438-M	—Rewinder Set Screw.
G-114-M	—Rewinder Spur Gear.
M-3	—Rewinder Handle.
N-108-M	—Internal Gear Shaft Nut.
M-1	—Internal Gear & Shaft (Includes C-128-M, S-438-M.)
M-6	—Rewinder Reel Shaft and Locks.
C-128-M	—Internal Gear Shaft Collar.
B-120-M	—Rewinder Bracket.
S-315-M	—Rewinder Fastening Screw Shoe.
P-3	—Rewinder Fastening Screw Complete.

PLATE 21

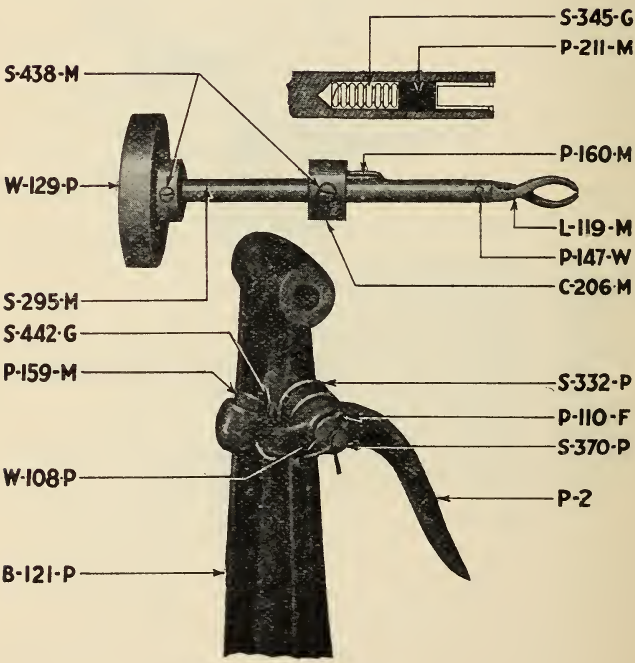

FIG. 215

SIMPLEX PARTS
(REWINDER)

Name

S-438-M —Rewinder Set Screw.
W-129-P —Friction Brake Wheel.
S-295-M —Rewinder Reel Shaft.
S-442-G —Set Screw.
P-159-M —Bracket Lever Leather Plug.
W-108-P —Friction Brake Lever Washer.
B-121-P —Rewinder Idler Bracket.
"P" —Rewinder Idler Bracket Complete.
S-345-G —Reel Shaft Plunger Spring.
P-211-M —Reel Shaft Plunger.
P-160-M —Reel Shaft Collar Pin.
L-119-M —Reel Lock.
P-147-W —Reel Lock Pin.
C-206-M —Rewinder Collar.
S-332-P —Friction Brake Lever Spring.
P-110-F —Cotter Pin.
S-370-P —Friction Brake Lever Stud.
P-2 —Rewinder Brake Lever.
P-1 —Friction Brake Wheel Assembly Complete.

PLATE 22

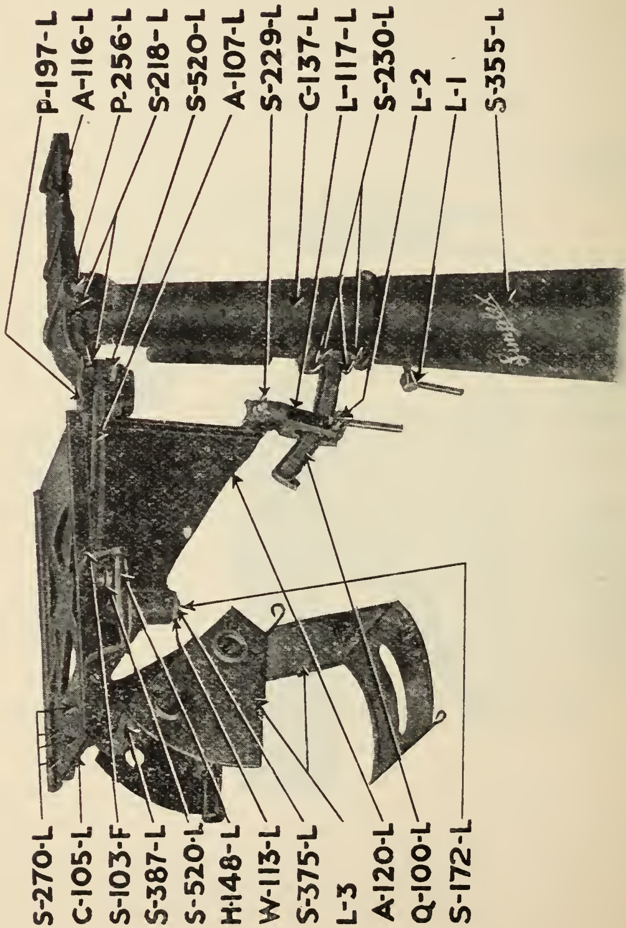

FIG. 216

SIMPLEX PARTS

(PEDESTAL)

Name

S-270-L —Switch Box Screw.
C-105-L —Lamphouse Carriage.
S-103-F —Lamphouse Carriage Handle Fastening Screw.
S-387-L —Knife Switch 60 Amperes.
S-520-L —Auxiliary Arm Pivot Screw.
H-148-L —Lamphouse Carriage Handle.
W-113-L —Lamphouse Carriage Washer.
S-375-L —Lamphouse Carriage Pivot Stud.
L-3 —Switch, Box and Cover Complete for 60 Amperes.
L-5 —Switch, Box and Cover Complete for 100 Amperes.
A-120-L —Slide Over Arm.
Q-100-L —Quadrant.
S-172-L —Lamphouse Carriage Retain Screw.
P-197-L —Slide Over Arm Pivot.
A-116-L —Pedestal Arm.
P-256-L —Pedestal Arm Pivot.
S-218-L —Pedestal Arm Pivot Set Screw.
S-520-L —Auxiliary Arm Pivot Screw.
A-107-L —Auxiliary Arm.
S-229-L —Quadrant Lock Retaining Screw.
C-137-L —Pedestal Column.
L-117-L —Quadrant Lock.
S-230-L —Quadrant Stand Screw.
L-2 —Quadrant Lock Clamp Handle and Set Screw.
L-1 —Pedestal Stand Handle and Set Screw Complete.
S-355-L —Pedestal Stand.

PLATE 23

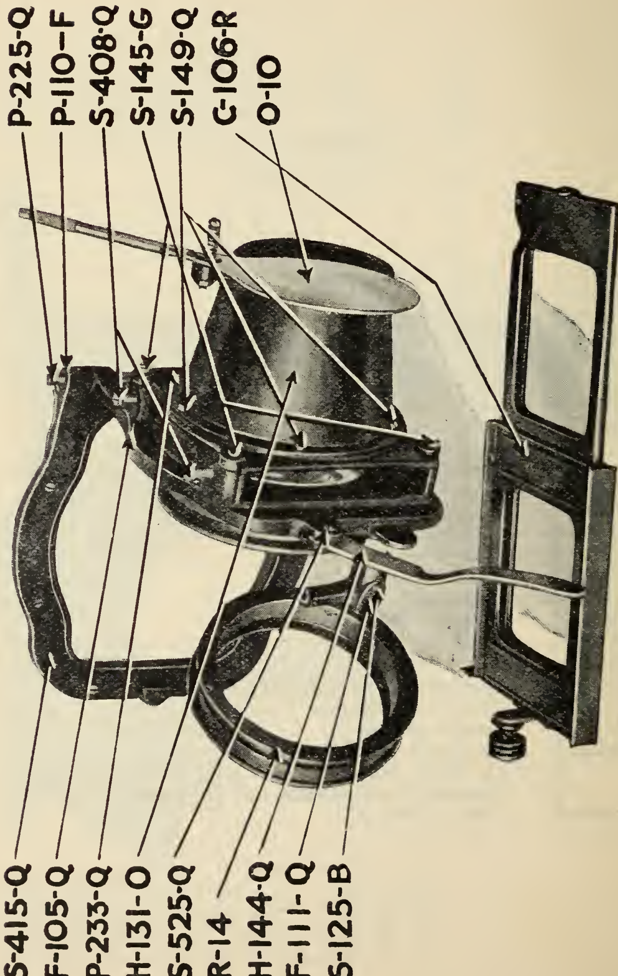

FIG. 217

SIMPLEX PARTS

(LAMP HOUSE)

	Name
S-415-Q	—Condenser Holder Frame Support.
F-105-Q	—Condenser Holder Frame.
P-233-Q	—Hood Plate.
H-131-O	—Lamphouse Hood.
S-525-Q	—Condenser Holder Frame Locking Pivot Screw.
R-14	—Condenser Holder Sets.
H-144-Q	—Condenser Holder Frame Handle.
F-111-Q	—Rear Condenser Holder Frame.
S-125-B	—Set Screw.
P-225-Q	—Condenser Holder Frame Hinge Pin.
P-110-F	—Cotter Pin.
S-408-Q	—Slide Carrier Retaining Screw.
S-145-G	—Hand Plate Fastening Screw.
S-149-Q	—Hood Fastening Screw.
C-106-R	—Slide Carrier.
O-10	—Lamphouse Hood Dowser and Handle.

PLATE 24

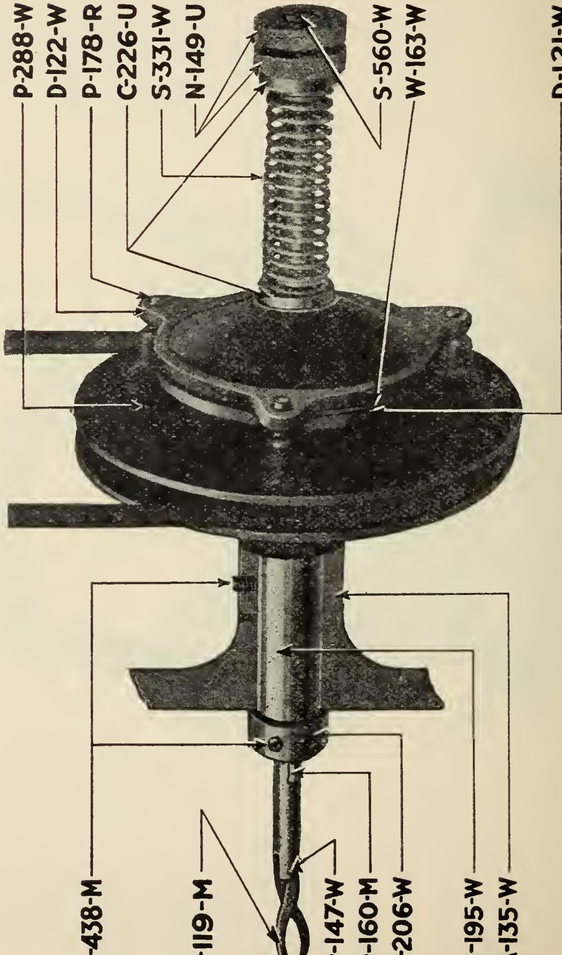

FIG. 218

SIMPLEX PARTS

(TAKE-UP)

Name

S-438-M —Set Screw.
L-119-M —Reel Lock.
P-147-W —Reel Lock Pin.
P-160-M —Reel Shaft Collar Pin.
C-206-W —Magazine Collar.
B-195-W —Take-Up Shaft Bearing Bushing.
A-135-W —Lower Magazine Arm, 16″.
P-288-W —High Speed Take-Up Pulley.
P-287-W —Low Speed Take-Up Pulley (Not shown on cut.)
D-122-W —Take-Up Floating Friction Disc.
P-178-R —Take-Up Pulley Pin.
C-226-U —Friction Adjusting Spring Collar.
S-331-W —Friction Adjusting Spring.
N-149-U —Friction Adjusting Spring Nut.
S-560-W —Take-Up Shaft.
W-163-W—Take-Up Friction Leather Washer.
D-121-W —Take-Up Shaft Friction Disc.
S-422-G —Set Screw for Friction Disc (Not shown on cut.)

PLATE 25

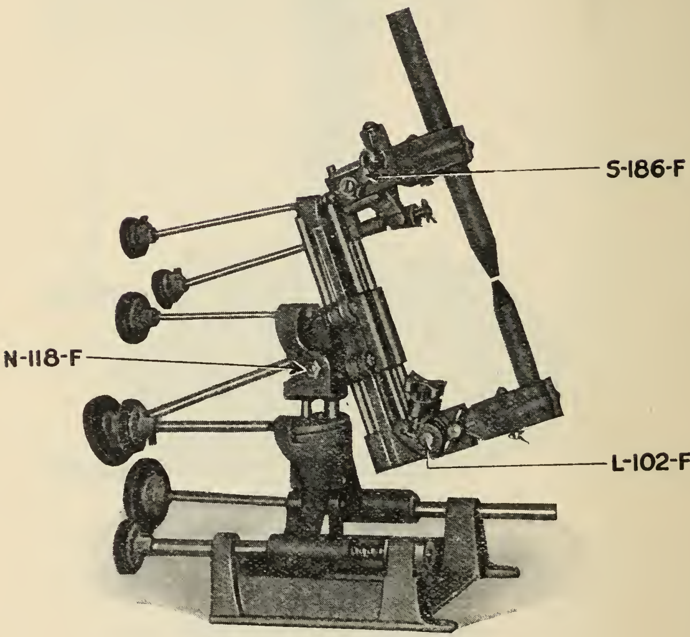

FIG. 219

SIMPLEX PARTS
(ARC LAMP)

Name

N-118-F —Carbon Feed Bracket Support Screw Nut.
L-102-F —Carbon Jaw Tilt Screw Lever.
S-186-F —Lower Carbon Holder Wing Screw.

INSTRUCTIONS ON THE USE AND CARE OF THE SIMPLEX MECHANISM

NOTE

All of the following instructions attending the removal of parts from the mechanism are written with the assumption that the mechanism is removed from the machine table or base, and assuming that the mechanism is in no way connected up with the motor or machine in any manner, for it will be noted that the illustrations in the following show only the mechanism and mechanism parts.

The numbers referred to in the following instructions are the regular catalog or price list numbers. It will be noted that in the mechanical illustrations are included each part number, indicated in such a way as to show the mechanical location of the part so designated. Adjoining these part numbers can be found the names, price and code word of each part, which listing is so compiled as not only to simplify the correct mechanical location of each part, but makes easier the matter of ordering the parts in question.

The instructions embodied in the following pages may seem in some instances a complicated series of prescriptions, but in practice they are quite simple, embodying, as they do, the exact procedure which is followed at the Simplex fac-

tory by assembly specialists equipped with knowledge through years of experience and training.

It will be noticed that the letter "P" follows each number referred to in the instructions. This is invariably followed by either of the following numerals, 1, 2, 3, 4, 5, or 6. This is merely a system of identifying any one of the six illustrations or plates upon which the part number referred to may be located.

TO REMOVE FILM TRAP DOOR, E-4, P.5

Push in knob S-134-E, P.2, which operation carries entire gate forward and out of way of intermittent sprocket, bringing gate into open position as shown on plate 2. Now lift upward against film protector P-214-E, P.5. Maintain this upward pressure until gate is lifted entirely free from confining pins, when it may be freely lifted out in its entirety. Should the gate stick or bind, it may be necessary to exert more than hand pressure, in which case it would be advisable to apply heavy screw driver against lower outside corner of door and tap upward.

CAUTION

Never force door upward by exerting pressure against film guide E-3, P.5, as this will surely spring same out of alignment, resulting in positive film damage, and much trouble in bending film guide back to properly conform with sprocket radius.

TO REMOVE INTERMITTENT CASING COMPLETE

Open both left hand doors of mechanism and remove screw S-209-G, P.3, and pull off gear G-112-G, P.3. Now pull down curved cover D-9, P.6, and hold same back out of way by placing any convenient heavy object upon it to prevent its flying back into upright position. Then push in knob S-134-E, P.2, which operation carries door out of way of interference with intermittent sprocket. Now loosen both screws S-157-B, P.2, and push both locks or ears L-116-B, P.2, out of way, so that they no longer engage framing ring R-133-A, P.1. Now turn fly wheel until set-screw in collar C-192-G, P.2 is facing front of machine, where it may readily be loosened with long-shanked screw driver. Then with body facing left hand side of mechanism, grasp fly wheel W-152-B, P.3 with right hand, and grasp gear G-133-G, P.3 with left hand, and pull toward body with both hands, this resulting in the removal of the entire intermittent casing, sprocket, and fly wheel.

TO REPLACE INTERMITTENT MOVEMENT COMPLETE

This, while a very simple operation, is one that requires absolute concentration in following closely the instructions below; inasmuch as the intermittent is the very heart of the mechanism, a slight oversight of any one replacement detail may result in serious damage.

First frame half way with framing rod, then hold intermittent unit by fly wheel in right hand, and gear G-133-G, P.3 in left hand, with gears meshed together. Now insert oil casing into

framing cam opening A-7, P.4 and insert shaft S-444-G, P.4 into bearing; then push both casing and gear G-133-G, P.3 into place together. At this point we come to a most interesting and necessary detail which is worthy of explanation; inasmuch as the completely assembled mechanism is "ground-in" at the factory, until certain vital gears are engaging smoothly and noiselessly with one another, and in order that the same teeth of these gears will be again enmeshed should the gears ever become disengaged a system of marking is resorted to, whereby an "O" mark is placed upon gear G-133-G, P.3 and also upon outer surface of fly wheel, this latter marking indicating a certain gear tooth on fly wheel gear G-148-B, P.4 which is quite hidden from view and therefore difficult in itself to mark.

It is now necessary to line these "O" marks up with one another in order that the original "ground-in" teeth of gears will engage as they did when mechanism was first assembled. This is done by turning gear G-133-G, P.3 around toward fly wheel, and then by pulling fly wheel outward until fly wheel gear is disengaged, turn fly wheel toward marked gear until the "O" mark on gear and the "O" mark on fly wheel are directly in line with one another. Now that these markings are lined up, pull gear G-133-G, P.3 outward, and turn vertical shaft gear G-120-G, P.4 until large end of the taper pin is same P-107-G, P.4 is directly lined up with "O" mark on gear G-133-G, P.3, after which push the latter gear into place, and also make sure that locating pin on the upper part of A-7, P.4 enters its engaging hole in intermittent casing rim, which places the casing in its

proper position. Now replace gear G-112-G, P.4, making sure that the squared-off face on inner side of gear locks into position with corresponding square clutch facing of main driving clutch C-126-A, P.4. Failure to properly engage these two clutch facings will result in both gears only partially meshing with resultant damage to teeth. Now replace screw S-209-G, P.3 and close both left hand doors of mechanism. This completes all of the operations on the left hand side of the mechanism. Now push locks L-116-B, P.2 back into place so that they engage with framing ring, R-133-A, P.1, and tighten up screws S-157-B, P.2, after which the collar C-192-G, P.2 is placed upon shaft of intermediate gear G-134-G, P.3, making sure that set-screw in collar is tightened against the flat surface of shaft.

ADJUSTING THE STAR AND CAM

The intermittent star and its mate, the cam, can easily be regarded as the most important units in the entire mechanism. The function of these two accurately-finished and almost microscopically-measured working parts is to pull the film down before the aperture position and hold it rigidly in a standing position while it is being exposed upon the screen. This means that during the showing of 1000 feet of film the intermittent movement must start and stop without back-lash or vibration 16,000 times. As can be imagined, this constant start and stop imposes a tremendous strain upon these two finely-adjusted and perfectly-finished parts, yet they are so constructed and of such splendid material that the well-known

Simplex star and cam with proper adjustment and perfect lubrication will stand for four or five years of constant use.

Care in adjustment must be exercised, for the very best results can only be obtained when the star is so adjusted, when its "locking" or radius surface bears upon the cam flange just sufficiently to allow a thin film of oil to work between the two surfaces. *Under no circumstances should the star be set up so tightly that there is even the slightest bind or "drag" apparent*, for it must be borne in mind that the movement, working at operating speed develops certain friction between the two surfaces of the star and cam. Friction develops heat, and heat in turn develops expansion, which if too great will tend to tighten up the intermittent movement.

To adjust:—loosen two screws, S-125-B, P.1 (being careful not to let them unscrew so far that they will drop out), then apply the fork end of Simplex spanner wrench to hexagon nut on eccentric bushing, B-4, P.4 and turn slightly either forward or back (very gently), until lost motion which is determined by rocking intermittent sprocket is quite taken up. Make sure when rocking or testing the sprocket that the star is in locking position, or in other words, that when turning the fly wheel the sprocket has entirely stopped turning and is in a position when the radius of the star is locked onto the flange of the cam wheel. Now tighten screws S-125-B, P.1 which completes the operation, but if tightening of screws should bind the star against cam, loosen screws again and allow for binding space.

REMOVING AND REPLACING INTERMITTENT SPROCKET

Should teeth on intermittent sprocket become worn, damaged, or under-cut, it is quite necessary that the worn sprocket be replaced with a new one. The replacing of the sprocket is an operation which is most simple, but it should only be attempted by one who is capable of exercising the utmost care, and equipped at least with the necessary tools. Preferably, the manufacturers of the Simplex would like users of Simplex equipment to have this change made either at the distributor's service station, or at the Simplex factory, but where either of these courses is impossible and a replacement is imperative, it must be understood that force and strength must not be applied in taking off or putting on the intermittent sprocket, depending rather upon patience and utmost care in accomplishing and completing a most satisfactory operation.

Remove the intermittent movement complete as described. Loosen two screws S-125-B, P.1 and making sure that these screws are entirely loosened, grasp intermittent sprocket (guarding particularly against springing shaft) and pull straight out, in this way removing bushing, star, shaft, and sprocket in one unit from the casing. Now lay sprocket upon a "V" block, and very gently drive taper pins out of sprocket. This process should be most carefully performed in order that the shaft is in no way "sprung," for should the shaft be the least fraction "out of true," a steady picture on the screen is absolutely impossible to procure. When the pins are re-

moved, grasp the bushing and star in the left hand, holding the parts with a piece of cloth to prevent slipping, and with the right hand twist the sprocket off gently, maintaining an easy upward pull at the same time. Now making sure that there are no burs or sharp edges in the pin holes in the shaft, push the new sprocket in place. Due to the fact that all work on the intermittent is done on a 1-10,000 basis, it may seem to the unpracticed man, that the sprocket is a little tight for the spindle or shaft. Should this be so, put a few drops of oil upon the shaft and very carefully entering the shaft into the sprocket, twist the sprocket on as far as possible until it sticks, then take the sprocket off and repeat this twisting operation, which if properly carried out, results in wearing down the 1-10,000th surplus thickness of the shaft, and results in a perfectly tight and secure fit.

Caution—Never force or drive the sprocket onto shaft. To do so will ruin both the shaft and sprocket.—After the sprocket is pushed onto the shaft sufficiently far to turn the sprocket so that the large diameter of the holes in the sprocket and those of the shaft are together. Gently drive pins into pin holes, with sprocket laid upon "V" block and unit is again complete. Now wipe the bushing and the star off clean, and lubricate same. Then push bushing into its bearing until the star is pressed against cam or pin wheel. Turn the fly wheel slowly, pushing in on sprocket until cam pin P-279-B, P.5 engages with slot in star S-551-B, P.5, when bushing can be pushed home; now

adjust star as already described, tighten up screws S-125-B, P.1, and replace intermittent casing as per instructions above.

INTERMITTENT SPROCKET LOOSE THOUGH STAR AND CAM ARE LOCKED

Due to excessive pull and undue strain upon the intermittent sprocket, it may be possible at some time during the life of the sprocket to develop a jump on the screen, although the star and cam are perfectly locked without any play being discernible between them. But it will be found that the intermittent sprocket itself is loose upon its shaft, although the pins which hold it to the shaft are apparently tight. This usually can be traced to the fact that the pull exerted upon the sprocket has worn the edges of the taper pin holes away sufficiently to create a slight play between the sprocket and the pins which fasten same upon the shaft. A close examination with an enlarging glass will show that the pin holes in the sprocket are worn egg-shaped, instead of perfectly round. In this case, drive out pins carefully with sprocket rested upon a "V" block, and with a proper-sized taper reamer, ream the hole out very carefully (and only sufficiently to again bring the holes to their rounded proportion), re-drive the pins, which will now set into the holes deeper than formerly due to the fact that the holes are now slightly enlarged; but it will be noted that the pins will set into their holes much more firmly and securely, thus eliminating the end-play. The reamers for the foregoing operation can be obtained through Simplex distributors.

TO REMOVE INTERMITTENT CASING COVER

To remove the intermittent casing cover B-8, P.4, remove intermittent casing complete as already described, and remove intermittent bushing, star, and sprocket as outlined in paragraph 5. In the hub of the casing cover will be found a hole (not the threaded one) into which is inserted the pin of the Simplex spanner wrench, which wrench is so shaped that it encircles the outer radius of this hub, and tap the wrench with a small hammer to start the cover. The screw in the cover being a standard right-hand thread, unscrews with the spanner wrench toward the left.

REMOVING CAM

To remove cam B-16, P.5, first remove the intermittent casing complete as directed above, next take out the bushing, star and sprocket, and unscrew casing cover as per instructions above. Now scratch-mark both intermittent gears to insure the same mesh when replacing. Then loosen set-screw in collar on end of star wheel cam, B-16, P.5. Remove this collar and grasp the star wheel cam, pulling same outward, which operation will remove the cam, gear and spindle complete.

TO REMOVE FLY WHEEL SHAFT

In removing the fly wheel shaft, S-454-B, P.3, follow out all instructions in the foregoing paragraph. Then remove or loosen fly wheel set-screw, S-512-B, P.3, and pull off the fly wheel, which will

carry with it gear, G-148-B, P.4, and the fly wheel shaft will easily drop out of opposite end of bearing.

TO REMOVE COMPLETE GOVERNOR UNIT OF VERTICAL SHAFT AND GEARS

Due to the fact that the governor, vertical shaft, and gears operating same are practically one unit, and the removing of any one of these parts requires the following-out of practically one general operation, it is best for the sake of brevity, and to avoid confusion and repetition, to describe the removal process in general. To remove any one of the vertical shaft or governor parts, it is quite necessary to strip the mechanism down to a state where sufficient working space is available.

First scratch mark all gears to insure the same mesh when replacing, then remove screws holding top plate P-207-D, P.6, then loosen set-screw S-146-A, P.2, and lift off focusing knob K-119-A, P.2, and remove left door link screw S-181-D, P.6. Now lift top plate off and remove complete intermittent movement. This last operation will expose the governor unit as pictured in plate 4. Then carefully drive out taper pin (or remove screw if machine is old model) from gear G-102-G, P.4 and G-120-G, P.4. Next remove center screws out of governor upper link holder H-121-G, P.3 (or drive out taper pin if mechanism is old model). Then grasp bevel gear No. 3-G-138-G, P.4 and pull upward. In this way, vertical shaft will pull out, thus releasing other connecting parts.

TO REMOVE BROACHED HOLE SPIRAL GEAR

To remove the broached hole spiral gear G-116-G, P.4, (which slides back and forth when framing). Loosen set-screw in collar C-193-G, P.3 and grasp bevel gear G-115-G, P.4, pull same to right, thus releasing shaft and gear in one unit, being careful not to lose washer.

TO REMOVE SPIRAL SHUTTER GEAR

To remove the large spiral shutter gear, G-147-G, P.4, loosen set-screw on this gear sufficiently to pull out shutter shaft S-574-G, P.2. Then remove left door link screw S-181-D, P.6, and remove upper and lower screws holding left front cover C-152-D, P.6. Now by removing cover the spiral gear can be lifted out.

TO REMOVE SHUTTER GEAR BRACKET

To remove shutter gear bracket B-122-G, P.2, remove gears contained in bracket, then remove washer and screw holding lever spring S-330-G, P.3, but be very careful in removing spring as this spring is most powerful. Keep hands entirely away and pry spring outward with long screw driver. If mechanism is late model a hole in right hand front cover C-159-C, P.6, will be noted on edge of cover where same adjoins left front cover edge. Directly in line within this hole will be noted framing slide lever set-screw, S-223-G, P.2. Insert screw driver through cover hole, loosen screw, and pull out stud which holds framing slide lever L-104-G, P.3 in place.

(Note:—If mechanism is earlier model, it will be necessary to remove right front cover entirely in order to release set-screw as described.) Now take out the framing slide lever and remove set-screws holding bracket.

TO REMOVE SHUTTER SHAFT

To remove revolving shutter shaft S-574-G, P.2, remove set-screw in large spiral gear, G-147-G, P.4, and pull shaft outward. (Note:—Set-screw in shutter gear referred to is quite short, and is fitted with pointed end, which end engages with counter-sunk hole in shutter shaft). It is advisable to take this screw entirely out, in order to avoid bruising the bearing end of shutter shaft should the pointed end of screw scrape against the shaft in pulling it out. This screw on account of its size is easily lost. *Put it in a safe place until again ready to use.* Old style machines have taper pins instead of set-screw holding shutter shaft.

TO REMOVE SHUTTER BLADE

Remove the ten screws from shutter blade if using old style shutter, and five screws S-192-D, P.2 if the new type of shutter is being used. This will immediately release the shutter blade from spider.

TO REPLACE SHUTTER BLADE

In replacing the shutter blade, make sure that the word "Simplex" (old style) or "Extralite Cutoff Blade" (new style) is directly in line with set-screws S-165-D, P.3 in shutter spider D-13,

P.4. Replace screws through respective holes in blade, thus fastening blade securely to shutter spider.

TO REMOVE SHUTTER ADJUSTING SLIDE BLOCK

To remove shutter adjusting slide block S-323-A, P.2, remove intermittent casing complete as already described. Then remove covers, C-157-C, P.6; C-152-D, P.6; C-159-C, P.6; and roller holder C-8, P.6. Then remove link-screw S-181-D, P.6 and take out framing slide lever L-104-G, P.3 as described above. Then drive out entirely the stop-pin which is located near upper edge of lower track in which the slide block operates. Loosen set-screw S-253-A, P.2 and turn shutter adjusting knob K-120-A, P.2 until all the thread on adjusting screw S-252-A, P.2 is entirely disengaged from within sliding block, when the block may be pulled out.

TO REPLACE FRAMING SLIDE LEVER

To replace framing slide lever L-104-G, P.3, first of all insert forked end of lever over the narrow end of rectangular toggle-block operating within crotch of lower side of spiral gear shaft washer W-105-G, P.3. Note that lever is slightly "rocker" shaped; before inserting the lever as above, make sure that the inner curve of the rocker-shaped lever faces toward fly wheel. Now replace stud, making sure that set-screw, S-223-G. P.2, sets securely into counter-sunk hole in the centre of stud, before setting this screw up securely. Now replace spring S-330-G, P.3 mak-

ing certain that hooked end of same engages around the outer curvature of framing slide lever. Then insert retain screw, S-145-G, P.3 and washer, making sure, however, that only about four threads of this screw are entered, in order to allow room for the setting of spring between the washer and slotted stud head. Now note free end of spring, which is approximately three inches long, is practically pointed downward. Grasp the free end of the spring in the right hand and make a complete turn or winding, which will result in the required tension for spring, and then snap the spring at the elbow of bent point into the recess located in the head of the stud. Tighten up set-screw while holding spring tightly in place, and lever is again in position.

TO REMOVE SHUTTER ADJUSTING SCREW OR SHAFT

To remove this shaft S-252-A, P.2, when a new sliding block is to be fitted into mechanism where filing may be necessary, follow out instructions in preceding paragraph. Then remove pad roller arm washer screw S-165-C, P.5 ON LOWER PAD ROLLER, lifting the pad roller up in order that rollers will clear sprocket teeth, pull entire pad roller unit outward and off its containing stud. Then loosen lock-nuts on threaded portion of shutter adjusting screw, and the shaft may be pulled out by grasping knob K-120-A, P.2.

TO REMOVE STEREO SLIDE

To remove stereo slide S-324-D, P.1, remove stop-screw S-106-D, P.1, and turn pinionn knob

K-102-A, P.1, so that stereo slide will work toward stop-screw location and until it is entirely free from its tracks, then slide attachment out. In removing this unit it will be noted that there is a small tension spring, which is set into depression located on smooth side of pinion rack. This spring must be replaced in its proper position when the stereo slide is again attached in place, in order to provide tension for the stereo attachment. Failure to replace this tension spring will result in the stereo lens "creeping" in and out of focus through machine vibration or angle.

TO REMOVE FRAMING CAM

To remove framing cam C-100-A, P.1, first remove complete intermittent casing as already described. Then remove connecting link screw S-223-G, P.3. Now take out screws holding left back cover C-151-D, P.6, and remove cover. Now insert thumb of left hand into mechanism and push framing slide lever L-104-G, P.3, forward as far as it will go, then insert block of wood approximately one inch thick between broached hole spiral gear G-116-G, P.4, and the inner edge of shutter gear bracket. This block will effectively hold framing slide lever to one side, thus relieving pressure of tension-block from edge of eccentric framing cam. Now loosen with a long slender screw driver set-screw in framing cam adjusting ring R-133-A, P.1, which operation unlocks ring when same may be unscrewed and framing cam may be slowly worked around until free of ring, when it is lifted out to the left.

TO REPLACE FRAMING CAM

To replace this cam it will only be necessary to reverse the order of the foregoing paragraph, but particular attention must be paid to the tightening of ring R-133-A, P.1. This ring should be tightened sufficiently to prevent any lost motion between casing and bearing, yet not so tight as to create binding during the framing-up process.

TO REMOVE AUTOMATIC FIRE SHUTTER LIFT LEVER

To remove automatic fire shutter lift lever E-7, P.1, remove lifting stud S-514-C, P.3. Then remove lever screw S-100-E, P.1, and then remove link retain screw S-102-E, P.1. When this latter screw is removed the fire shutter, released of its connection, will drop down, and lever may then be pulled outward toward the right.

NOTE:—If mechanism is old model, the lifting stud S-514-C, P.3, is not present, but in its place is a set-screw which is removed after taking off left back cover C-151-D., P.6, as described in paragraph 20.

TO REMOVE AUTOMATIC FIRE SHUTTER

To remove automatic fire shutter S-316-E, P.1, remove link retain screw S-102-E, P.1, then remove entire lateral guide roller unit as described in next paragraph, lift fire shutter up out of confining tracks.

TO REMOVE LATERAL GUIDE ROLLER UNIT

To remove any one of the individual parts of the lateral guide roller unit, it is necessary to go through the same general operation. To remove: Loosen set-screw S-192-D, P.1, and set-screw in stop-collar on opposite end of shaft, insert screw driver against left hand end of shaft, starting same outward, grasp free end of shaft with pliers and pull out entirely. This operation will cause all of the lateral guide roller units to become disconnected.

NOTE:—The location of the roller spring S-337-E, P.1, and stop-collar on same plate, should be noted before this unit is disturbed, in order that rollers, spring, spacing-bushing, and stop-collar will again be assembled in their correct formation. This precaution is necessary to insure the absolute lining-up of film with film trap below, and eliminates any chances of side motion of film, which would be highly undesirable upon the screen.

TO REMOVE GOVERNOR LIFT LEVER

To remove governor lift lever D-2, P.4, remove lower hinge screw S-101-C, P.4, and also pivot screw S-150-D, P.4, which releases lever so that same may be lifted out.

ADJUSTING FRAMING HANDLE TENSION SPRING

The function of this spring S-341-G, P.1, is to provide the necessary tension required in the

operation of the framing handle arm A-118-G, P.2. Should the framing device "creep-up" during the operation of the machine, instead of remaining in the one position, it would indicate lack of tension. On the other hand, too much tension would result in "sticking" or binding of the framing device. In either case, to adjust:— Remove retain screw S-209-G, P.3, and take off main driving gear G-112-G, P.3. With this removed, we can now see the framing handle pivot P-196-A, P.4, exposed, upon which are located two hexagon nuts. One of these nuts (the outer one) is the lock-nut, while the underneath one is the adjusting or tension nut. The adjusting nut should be set up just tightly enough so that in operating the framing handle C-11, P.2, there should be enough tension present so that a fairly firm pressure is required to operate the handle without a feeling of binding being apparent.

TO REMOVE FRAMING HANDLE TENSION SPRING

To remove framing handle tension spring S-341-G, P.1, follow out the foregoing instructions referring to removal of gears, and unscrew both hexagon nuts referred to, when spring may be pulled out. In replacing, make sure that a washer is placed on each end of the spring.

TO REMOVE FILM TRAP COMPLETE

It may be necessary at some time or other to remove the entire film trap unit which is indicated as E-1, P.1. It is upon this unit that the film shoes

are located, while several important parts relating to the film trap door E-4, P.5, are also connected with this main unit.

There is really very little occasion for the removal of this entire film trap, but should such occasion arise it must be kept very firmly in mind that the lining-up process as described in paragraph 32 is of great importance, inasmuch as imperfect alignment will result in an in-and-out-of-focus effect upon the screen which can only be remedied through the proper adherence to the prescribed directions.

To remove:—First remove film trap door as indicated in beginning of these instructions, then remove screws and cover C-151-D, P.6, also the two screws that hold top of film trap, which fastens through roller holder C-8, P.6. Now disconnect the fire shutter lift-link by removing lifting stud S-514-C, P.3. Also unlatch and throw back right back cover D-9, P.6.

REPLACING FILM TRAP UNIT COMPLETE

Then remove both film trap screws S-133-C, P.4, and lift the entire film trap out of its position by pulling it to the right in order to avoid bending the lift-link arm in its confining slot. With the film trap removed, it is now an easy matter to remove or replace any of the separate units that go to making up the complete film trap.

Before replacing the film trap complete, it will be well to consider the purposes for which this important unit has been designed. A close examination of the inside or surface side of the film

trap, will show that much thought has been given to the designing and finishing of this surface, which must of necessity be perfectly smooth as well as accurately squared and lined up. It will be noted also that the section of film operating between the intermittent sprocket and upper loop is the section which intermittently stops and starts while the balance of the active film moves constantly. With this intermittent sprocket action pulling the film into aperture position with a sudden start, and stopping it just as quickly, there naturally is a tendency to create either a slight vibration or a buckling of the film, which in reality is similar to holding a loose loop of string between the two hands and suddenly jerking it taut, when it will be noticed that the string vibrates considerably. It must be realized also that any movement on the part of the film at the aperture position, being magnified so greatly upon the screen, does much to prevent a perfectly steady picture. In order that the film will be at perfect right angle with the lens or optical train, and so that the tension or film pads will function at their best, it is necessary that the replacing of the film trap unit be followed out with extreme care as to its proper alignment.

To replace:—The really important fact to bear in mind, is the lining-up process which is followed after the two film trap screws S-133-C, P.4, have been entered into place. These screws together with several locating pins hold the film trap in position so that the alignment is made possible at this time. Now by turning to Plate No. 2 we see the mechanism as it appears with the film

trap in position and the film door open. It will be noted also that the outer radius of the intermittent sprocket is directly in line with the outer surface of the film trap shoe, which position is the one called for in a perfect alignment. To determine whether the film trap is lined up accurately, place the edge of a 6″ steel rule or scale upon the film trap shoe S-309-E, P.5, in such a manner that the lower edge of the scale projects beyond the shoe and rests on the outer radius of the intermittent sprocket directly under the film trap shoe. This test should be made when the intermittent sprocket is at a point where in framing it does not carry toward the screen but is carried by the eccentric toward the lamphouse. If the trap is in proper position, there is absolutely no space discernible between the edges of the steel rule and the film shoe. If, however, there is even the slightest space apparent, it means that the film trap is out of line, and can be brought into alignment by slightly loosening the film trap screws S-133-C, P.4, and tapping the film trap either on the top or bottom until properly squared or lined up. This alignment once acquired, it is only necessary to tighten the film trap screws securely and replace all mechanism parts by reversing the order of instructions given above.

TO REMOVE FILM TRAP STUD

After following the instructions above, it is now possible to remove the film trap stud, which is connected to mechanism by film trap stud screw S-134-E, P.2, and which stud also carries film trap door holder.

To remove any one of these parts it is only necessary to unscrew stud screw S-134-E, P.2, which screw has a knurled head. This screw may be loosened by inserting either a piece of cloth or paper (to prevent defacing metal) between the jaws of a pair of good-sized gas-pliers and unscrew to the left. This process removes the screw, and releases the spring within the plunger thimble. With this spring tension removed the film trap door holder and stud may be pulled out from the front of mechanism.

FILM TRAP SHOES

The film trap shoes S-309-E, P.5, comprise one part of the mechanism that is subjected to much more wear than any other. It is upon these shoes or tracks that the moving film is riding while it is approaching or leaving the aperture position. Due to the tension which is maintained at this point, in order to eliminate any film movement or vibration, the film is firmly pressed against the film shoes by the film pad P-100-E, P.5. In time these shoes will wear and in the wearing develop either grooves or hollows in various parts of their surfaces. This condition will result in possible film damage, or at the best an in-and-out of focus effect, and when this condition prevails the shoes should be either "turned" (if new style) or replaced, if old style shoe is used.

TO REPLACE OLD STYLE SHOE

This type of shoe is fitted with bevel edges, which edges slide into a slotted groove in the film

trap. In removing a worn shoe of this kind, remove the stop-screw S-432-E, P.1, and also remove the lateral guide rollers and then remove lower pad roller by unscrewing pad roller screw S-217-E, P.5, and withdraw the roller P-102-C, P.5, and remove intermittent casing complete as described in beginning of these instructions. This latter operation removes the pad roller so that the film shoe may be slid entirely out of its confining grooves and another shoe inserted in its place, neither this type nor type "A" shoes is reversible.

TO REPLACE NEW STYLE SHOE

The new style shoe is so designed that when one surface shows signs of wear the shoe may be turned or reversed until all four edges of shoe are worn. This type of shoe may be removed by taking out the three screws S-432-E, P.1, which screws are located in the front of the film trap. In turning a shoe it is quite possible to use the same retaining screws, but should a new shoe be inserted it is best to remove the lateral guide roller unit. This is removed due to the fact that when the new screws are tightened up through a new shoe, there may be occasions when the point or end of the screw will project slightly beyond the wearing surface of the shoe. In this case it is necessary to dress the screws down so that they will be flush with the shoe surface. This dressing down may be done with a very fine small flat file, and in filing, be sure to remove the lateral guide roller in order to avoid marring the edges of the

roller while filing. Also make sure when all the screws in the shoes are tightened up that the shoe is in no way "buckled" but is lying perfectly flat and is evenly drawn against the film trap along its entire length.

INTERMITTENT SPROCKET TENSION SHOES

The intermittent sprocket tension shoe or film guide shown as E-3, P.5, is attached to the lower apron of the film trap door. These shoes are confined within the curved radius of the lower apron and they act upon the intermittent sprocket as the pad roller acts upon the upper and lower feed sprockets. In other words, the tension shoe keeps the moving film from jumping off the sprocket when the film is in action. Too much tension will tear the film, while too little tension will result in unsteadiness upon the screen, or the loss of the lower loop. It will be noted that the two outer rims of the shoe are higher than the inner rims, so all adjusting must be centered upon these outer rims, whose radius is the same as that of the sprocket. When in perfect adjustment, the shoe should move backward about 1/64 or 1/32 of an inch against the sprocket when gate is closed securely without film, but make sure that the spring tension is fairly light.

TO ADJUST:—Remove retain spring screw S-162-E, P.5, and compress or relax retaining spring S-326-E, P.5, until the required tension on both sides of shoe is apparent.

ADJUSTING PROJECTION LENS HOLDER

Lens holder A-4, P.2, operates upon a sliding block and obtains its movement through the turning of focusing knob K-119-A, P.2. This lens holder or barrel is really a split tube into which the lens tube (without jacket) is placed after first loosening screw S-165-A, P.2. Within the lens holder are contained several adaptors or bushings, so fitted to accommodate lens tubes of various circumferences. In placing the lens tube into the holder follow the formula provided under the heading of "Lens Assembly." Now operate the sliding block by turning knob K-119-A, P.2, until the lens holder is midway upon its tracks or in a neutral position (this to provide for sufficient focusing latitude), and then light the arc lamp, lift up fire shutter and project light upon screen, meanwhile sliding lens forward or backward inside of lens holder until the outlines of aperture are clearly defined upon the screen. Then tighten screw S-165-A, P.2, which completes operation of inserting lens. This operation is to be followed out while there is no film in the mechanism. The final focusing may then be completed by turning knob K-119-A, P.2, when the film is in operation.

NOTE:—When lens is in correct position it is well to mark the lens by scratching with a pointed instrument at the place where lens protrudes from lens holder. This mark will come in very handy when occasion arises for removing and replacing the lens.

ADJUSTING UPPER AND LOWER SPROCKET ROLLERS

The upper and lower sprocket rollers P-102-C, P.5, are important units of the Simplex mechanism, inasmuch as they function to keep the film properly riding over the sprockets while the mechanism is in operation. In order to avoid film damage and to prevent the losing of the upper or lower loops, it is essential that these rollers be properly lined up and adjusted. The adjusting of the rollers is a very simple procedure and the one important fact to bear in mind is that the distance from the rim of the roller to the face of the sprocket should be about one thickness of film. The proper adjustment of these rollers is quite necessary, particularly on the lower sprocket, where not only much annoyance but great film damage can result if the rollers are not lined up properly. Losing the lower loop through the film "climbing the sprocket" is due very often to improper pad roller adjustment; the roller is either out-of-line with the sprocket or its distance from the sprocket is too much or too ilttle. Never allow the sprocket roller to "ride the film," that is, to bear upon the moving film with undue pressure, for this pressure if greater on one side will in every case cause the film to either jump or climb from the sprocket at the passing of the very first bad or improperly made patch.

TO ADJUST

The upper pad roller is adjusted by means of sprocket roller arm screw S-194-C, P.5, which screw operates against the pad roller stud, and

can be so adjusted as to alter the distance between the pad roller and the sprocket when the pad roller is clamped down into operating position. Before turning the set-screw in question it will be necessary to loosen up the lock nut, which nut may again be tightly screwed into place as soon as the proper adjustment has been reached, and through the use of this lock nut it is possible to maintain the proper adjustment for an indefinite period.

The lower pad roller is adjusted in a similar fashion, the only difference being that the set-screw in the lower roller arm faces in an opposite direction as does the upper. The adjustments described in the foregoing apply only to the lateral alignment with the sprocket, but in order to obtain perfect results it must be kept in mind that the teeth of the sprocket operate between the grooves or flanges of the rollers, and should these flanges be out-of-line with the sprocket teeth it will be necessary to make sure that the pad roller arm is properly lined up, by examining screws, S-248-C, P.5, S-165-C, P.5, and S-217-C, P.5, all of which screws when properly tightened will result in keeping the pad roller in perfect alignment with the sprocket teeth.

REMOVING UPPER ROLLER ARM TENSION SPRING

The upper pad roller arm A-136-C, P.5, is held into operating position by means of tension exerted by roller arm spring S-570-C, P.2. Should the removal of this spring be required, it is necessary to remove film trap complete, as already

described, and remove the two spring retaining screws, but if an offset screw driver is used it will only require the removing of C-8, P.6, without disturbing film trap.

TO REPLACE

When replacing the spring, make sure that the retaining screws are fully tightened up, and note that the spring is much more easily attached when the roller arm is closed or in operating position.

REMOVING LOWER ROLLER ARM TENSION SPRING

The lower pad roller spring, S-569-C, P.2, is held in place by retaining screw, which screw may be removed by taking off front cover, C-159-C, P.6, which permits for sufficient working space to accomplish the operation.

TO REPLACE

In replacing spring press the roller arm down, or put it into operating position, for in this way the tension upon the spring is lessened, making the attaching of the spring a much easier process.

SETTING REVOLVING SHUTTER (BY FORMULA)

In setting or "timing" the revolving shutter, it is necessary to bear in mind that regardless of the type of shutter used there is only one cut-off or main blade that is used in timing the shutter. This blade is marked with the Simplex trade-mark where an opaque type of shutter is used, and is

marked "Cut-off-Blade" when the Extralite Shutter is used. This cut-off blade is used to shut off from the screen the movement of the film as it is pulled down into aperture position by the intermittent sprocket. The shutter must be so "timed" that the cut-off blade covers the aperture opening while the downward movement is going on, and uncovers the aperture opening when the film has stopped moving and remains exposed for a brief instant at the aperture position. In order to accomplish this end, it is necessary to set the shutter with the movement of the intermittent sprocket. The quickest and easiest way to make a general setting is to set the framing-handle, C-11, P.2, at center or in a neutral position. Move the shutter adjusting slide or block, S-323-A, P.2, by means of knob, K-120-A, P.2, so that sliding block is at a point equi-distant between the two stop-pins in center frame between which pins the adjusting block operates. Now bear in mind that four teeth on intermittent sprocket represent one full move of any one of the four radii of the star wheel. Turn the fly wheel by hand and keep eyes on intermittent sprocket; watch closely when it starts moving and when two teeth have moved downward stop turning, and place the shutter on shutter shaft so that the moving picture lens sets exactly in the center of the cut-off blade. Tighten set-screw on shutter, and if the position of the sprocket or the shutter has not been disturbed, it will be found that during the movement of the intermittent sprocket the lens is entirely covered by the cut-off blade and entirely uncovered when the sprocket is at rest.

SETTING SHUTTER BY SHUTTER SETTING DEVICE

It may be found that after following the directions in the foregoing some little inaccuracy or miscalculation has resulted in the shutter not being entirely in "time" with the intermittent sprocket. This out-of-time condition is indicated by "travel-ghost" upon the picture screen, which ghost makes itself apparent in the form of elongated flashes that streak out from any white object that might be present in the picture. These streaks or flashes are usually made apparent in a white lettered title with a black back-ground. The direction (up or down) of these streaks indicates whether the shutter uncovers the lens too quickly before the film has come to a stop, or does not cover the moving film quickly enough. In order to remedy this condition it has been suggested in paragraph 40 to place the adjusting block, S-323-A, P.2, in a position midway between the stop-pins. The reason for this position is now apparent, for it leaves sufficient latitude both ways, so that by turning adjusting knob K-120-A, P.2, the travel-ghost may be effectually eliminated.

FOCUSING MOTION PICTURE LENS

The proper focus on the motion picture screen may be obtained through turning knob K-119-A, P.2, which operates lens holder backward or forward, until clear definition is obtained. Should this operation fail in producing the required results, check up the lens setting by following in-

structions as contained under "Lens Assembly," and also read carefully the subject matter headed "Adjusting Projection Lens Holder."

FILM TENSION PAD

During the functioning of the intermittent sprocket in pulling the film down into aperture position, its action is to jerk approximately ¾ of an inch of film down at each movement. This amount of film is of course taken from the upper loop for the time being and added to the lower loop. The action upon the film through this operation is fully described in paragraphs 32 and 34, the reading of which paragraphs will at once impress the reader with the importance of proper tension of the film pad, P-100-E, P.5. Too little tension on the film pad will result in a slight vibration of the film after the intermittent sprocket stops (which vibration of course shows upon the screen), while too much tension will tear film sprocket holes, wear out sprocket teeth, and impose an abnormal strain upon the entire mechanism. According to experts, the proper tension is had when the mechanism is operated at a speed up to 100 R. P. M. and a steady picture is apparent. At speeds exceeding 100 R. P. M. (which are abnormal) the film will naturally show a tendency to act differently than when operated under normal speed. All Simplex mechanisms are tested at the Simplex Factory at a maximum speed of 120 R. P. M. and the tension provided as a flexible one that offers latitude sufficient for excessive low up to maximum high speeds with desirable screen results.

ADJUSTMENT: — The required tension for film pad P.100-E, P.5, is provided by film trap door pad spring S-328-E, P.5. This spring may be removed or replaced by removing film trap door E-4, as described in beginning of these instructions. Remove both retaining spring screws and attach new spring. All tension is obtained by bending springs slightly more or less until the desired results are accomplished, while spring is attached.

ADJUSTING STEREO LENS

To adjust stereo lens, first follow instructions under heading "To Assemble Stereo Lens." To center slide opening upon the screen, loosen clamp wing screw S-155-R, P.1, and swing lens holder R-5, P.1, either to right or left, and when center location on screen is obtained tighten up wing nut. To obtain up or down position on screen, raise stereo arm A-122-D, P.1, by turning adjusting screw S-264-D, P.1.

TO FOCUS

Loosen wing screw S-155-R, P.1, and slide stereo unit complete forward or back upon stereo rod R-127-R, P.1, until slide opening is clearly defined upon the screen. Tighten up wing screw and procure finer definition by turning focusing knob K-102-A, P.1.

REMOVING STEREO SLIDE UNIT

To remove stereo slide unit S-324-D, see paragraph "To Remove Stereo Slide."

REPLACING STEREO SLIDE UNIT

In replacing the stereo slide, it is only necessary to reverse the order as indicated in paragraph above, but attention is called to the small tension spring or "gib" which is placed in its depression in the toothed bar between the tracks. This spring must be replaced in its proper location in order to provide tension for the stereo slide which unless supplied with the required tension could easily be jarred out of its once fixed position, particularly if machine is projecting on an extreme downward pitch.

TWO APERTURE PLATE SIZES

Simplex aperture plates are made in two sizes. One, the commercial size, is equipped with an opening exactly .9062 inches wide by .6796 inches high, the height being ¾ of the width. This is the finished aperture plate which is included in the regular Simplex equipment; the other type is the "under-sized" aperture plate, which is really the finished blank with the exception that the aperture opening has not been refined to the commercial size. The opening in the under-sized plate is approximately 1/32 of an inch smaller and is used where a "keystone" effect is produced upon the screen due to an extreme angle pitch. This "keystone" effect can be somewhat reduced

or squared-up by using an under-sized aperture and carefully filing with a very fine draw file the aperture opening on the under-sized plate, so that the picture frame will show less "keystone" or distortion. Whenever the aperture filing remedy is resorted to it is advisable to use the "under-sized" plate, for if considerable filing should be done on a commercial aperture or regular sized opening, there is a likelihood of the sprocket holes showing upon the screen, or at the best, the picture would be somewhat out of proportion.

CAUTION:—The filing of the aperture should only be attempted by using the proper kind of draw file, and by one who is willing to use the utmost care and patience, for successful filing of an aperture is indeed a delicate operation.

TO REMOVE APERTURE PLATE

In the older model Simplex mechanism the aperture plate being a part of the film trap is not interchangeable, but the latter models are equipped with aperture plates which set into the face of the film trap E-1, P.1, and can be readily removed and replaced when worn.

TO REMOVE:—Follow instructions in paragraph regarding the removal of film trap shoes. After removing the shoes it can be seen that the aperture plate is fastened with two small screws. These screws can be removed by taking the projector lens out of the lens holder A-4, P.2, by loosening screw S-165-A, P.2. With the lens removed it will be noted that the two

aperture screws are in a direct line with the lens holder, which with the lens removed is now empty and through which a long screw driver may be inserted and the screws removed.

NOTE:—In replacing the aperture plate, make sure that the screws are tightened up sufficiently to draw the aperture plate firmly against the film trap recess, in order that the aperture plate does not protrude in a manner to interfere with the film passage.

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INSTRUCTIONS ON THE USE AND CARE OF THE INTERMITTENT MOVEMENT

The importance of the intermittent movement has already been touched upon in several places throughout these pages, yet the builders of the Simplex feel that a "close-up" showing the cut-away oil box, which reveals the inner mechanism will add greatly in following out the general hints for replacements and up-keep which the experienced Simplex factory experts have compiled.

It will be noted that in the illustration, the star and shaft have been removed in order to show the internal gearing more clearly, while in order to gain more space the fly wheel has also been removed from the shaft. This illustration shows very minutely through means of a "phantom" retouching the oiling or lubricating system, and we cannot say too strongly that *proper lubrication of the intermittent will eliminate* 50% *of the usual troubles.* Study the lubrication system carefully. Note that one oil tube conducts the oil into an oil chamber which lubricates the upper bearing or fly wheel shaft (S-454-B), and the oil working its way down into the lower bearing where it lubricates the cam or pin wheel shaft (C-225-B).

The other oil tube (the bent one) conducts the oil into the interior oil casing, and is set into the casing in such an angle as to allow the oil to run into any one of the numerous oil holes in the hard-

ened star wheel bushing (B-4). This lubricates the star wheel shaft (S-551-B). The oil from the bent tube also flows into the oil casing which fills up sufficiently to partially submerge the cam wheel which in revolving splashes the oil onto the star, thus providing ideal lubrication for these parts.

Warning—In oiling the intermittent, do not use the old style can. It has been proven hundreds of times that oil from a dirty oil can, with a dust-covered nozzle has caused serious damage through some particle of dust working its way into the smoothly finished working surfaces. *Use an ordinary glass medical syringe with a hard rubber tube and plunger.* The use of such a syringe en-

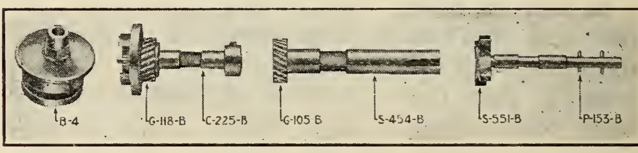


FIG. 221

ables one to see how much oil goes into the tubes, and by holding up to the light one can readily see whether or not the oil is clean.

In replacing gears or shafts on the intermittent, remember that the close fitting qualities of Simplex parts assure the user of long service and high efficiency. If any of the new parts seem too tight, just use a little patience and follow instructions faithfully.

Above all—never force or drive a tight fitting part. See that the fly wheel shaft S-454-B, and star wheel shaft C-225-B, fit the bearings without lost motion. If too tight, apply a small quantity

of rotten-stone which has been mixed to a paste body with a good grade of lubricating oil (preferably Simplex). Insert whichever shaft may be tight, or both as the case may be, and work the shaft in and out for a few minutes, giving the shaft a slight turn now and then to equalize the lapping. When the shaft has been worn down in

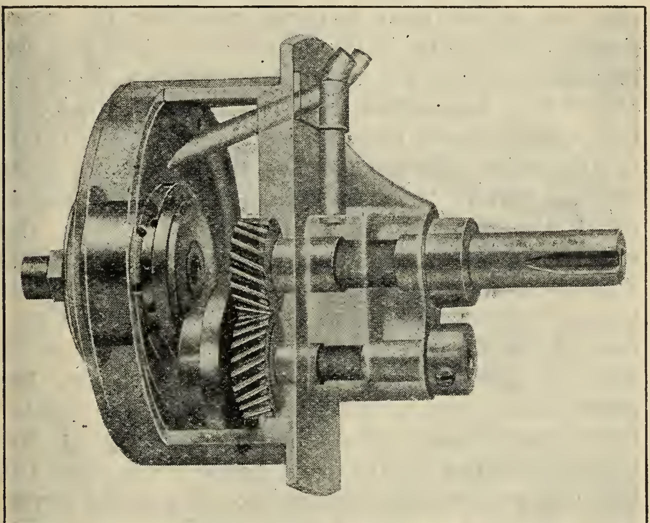


FIG. 220
Oiling Principle of Simplex Intermittent

this manner so that it feels free without any bind being apparent, remove the shaft from the bearing and thoroughly clean the bearing and shaft surfaces with kerosene or gasoline. After washing with gasoline the shaft may still seem a little tight, due to the dry condition of the bearing, and

in such a case it would be advisable to put a drop of oil upon the shaft before inserting same then making sure that the shaft revolves freely without binding, and if there is a bind the lapping operation should again be resorted to.

When satisfied that the shafts are sufficiently "lapped-in" and thoroughly cleaned and oiled, attach the fly wheel to the fly wheel shaft and mesh the cam wheel gear G-118-B with the fly wheel gear G-105-B and turn fly wheel in order to determine whether the gears are meshing smoothly, and it may be advisable to try meshing the gears into various teeth until an equal amount of "bind" is apparent. Now turn the fly wheel until the driving pin in the cam wheel is directly underneath the inner spout of the bent oil tube, and with a needle or other sharp instrument scratch a semi-circle around the outside circumference of the cam wheel making the scratch on the flat surface of the fly wheel gear. This scratch or mark will aid greatly as a guide when replacing the gears after they have become dismantled. After these operations, take a small quantity of Arkansas Powder mixed to a paste body with oil, hold the entire intermittent box at a slight downward angle to prevent the grinding compound from entering the bearings, apply the grinding compound to the gears turning the fly wheel in order to distribute an even amount of paste into the gear teeth. Then grasp the fly wheel firmly and keep turning same backward and forward until the gears are running smoothly without lost motion. Then dismantle all parts and clean thoroughly with kerosene and repeat the grinding-in process if necessary, making sure in reassembling

that the same gear teeth are meshed by following the scratch mark as described in the foregoing. If the gears are uneven or in other words tight in some spots, apply the grinding compound on the tight spots only.

Do not use any other compound than Arkansas Powder for grinding gears and be sure that all parts are thoroughly clean after grinding.

For lapping the bearings, do not use any other compound than rotten-stone and make sure that all bearings and parts are thoroughly clean before replacing.

Both compounds mentioned in the above can be procured either through Simplex Distributors or at the Simplex Factory.

DONT'S FOR OPERATORS

1. Don't operate machine with mechanism doors open or unlocked.
2. Don't start machine until complete threading course has been checked up.
3. Don't lift up fire shutter while film is in mechanism and lamphouse dowser is open.
4. Don't start machine until picture is in frame.
5. Don't use force in driving pins or removing shafts.
6. In removing intermittent sprocket be careful not to strike it against sides of machine.
7. Don't fail to examine and test your machine before starting each show. It will save trouble and is required by regulations in some cities.
8. Don't start your machine with a jerk, but increase the speed after the machine is in motion.
9. Don't have too much tension on pad or film guide. This causes undue wear on the star wheel and intermittent sprocket, and may injure the film.
10. Don't let film trap slam after threading, as the film may be thrown off sprocket and ruined when machine starts. Place finger against film trap and let it close easily.
11. Don't forget to lock right back cover D-9, P.6 when machine is running.
12. Don't use steel to scrape the emulsion off on the film trap and tension springs. Use edges of a coin or piece of copper or other soft metal.
13. Don't force your machine when it seems stiff.

It may need oil or an obstruction may have found its way into the working parts.

14. Don't forget to re-time or set the shutter after removing the intermittent case from the machine.

15. Don't use graphite in any part of the mechanism. It will not only ruin the gears, but will eventually destroy the bearings and entire mechanism.

16. Don't use alcohol, benzine, kerosene or turpentine as a lubricant. Either Simplex Oil or oil of a similar quality is the only machine lubricant recommended.

17. Don't use oils "that clean as well as lubricate." Any oil that is powerful enough to eat rust will also eat any of the bearings and shafts.

18. Don't fail to give mechanism a kerosene bath at least once a month. You'll be surprised.

19. Don't try to put enough oil into mechanism at one oiling to last a week, but use less oil and use it oftener.

20. Don't forget any of the oil holes. They are there for a purpose and every one of them is important. Locate each one of them on the instruction plates.

21. Don't fail to oil machine every time before using, particularly the intermittent movement, "The heart of the mechanism."

22. Don't put vaseline, grease or packing of any kind into the intermittent casing.

23. Don't allow oil to touch friction disks of speed control.

24. Don't fail to keep intermittent casing half full of oil.

25. Don't use oil on the arc lamp, as it quickly

burns off and causes lamp to bind. For the arc lamp, use graphite for lubrication.

26. Don't fail to keep lenses and condensers clean at all times.

27. Don't use a rough cloth or waste to clean these optical units. A piece of chamois, linen or soft cloth moistened with ammonia will give the best results, and remove all dirt as well as giving a high polish. Use equal parts of ammonia and water.

28. Don't fail to examine all electrical connections on lamp, rheostat or motor. For any elec-

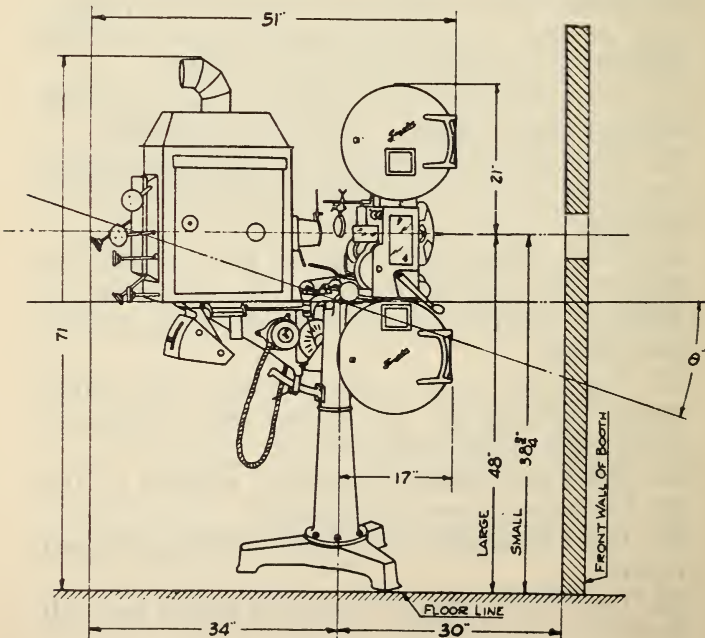


FIG. 222

trical device to be efficient all connections must be firmly tightened.

29. Don't allow water or any dampness to penetrate the rheostat or motor.

30. Don't fail to keep the commutator and brushes on the motor perfectly clean.

31. Don't allow the brushes to wear down too low, or commutator will become pitted and the motor will lose speed and be ruined.

32. Don't hold the idler pulley to slow up on titles, as this imposes a strain on the motor. Use the speed control.

33. Don't fail to oil the armature shaft frequently.

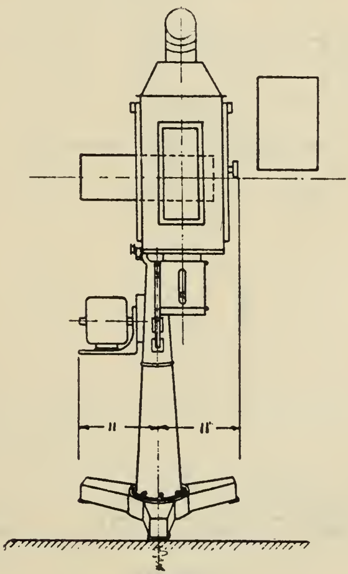


FIG. 223

34. Don't neglect the arc lamp connections. High amperage eventually chars the asbestos lead nearest the lamp and efficiency requires that a new connection be made every week.
35. Don't use oil or grease on lamp joints or rods. Use a little powdered graphite at the joints.
36. Don't allow carbon dust or other dirt to accumulate in the lamphouse. A small pair of hand bellows will readily blow out all dust.
37. Don't have any loose contacts or burnt asbestos leads on the lamp. Burnt or broken leads mean trouble while machine is in use.

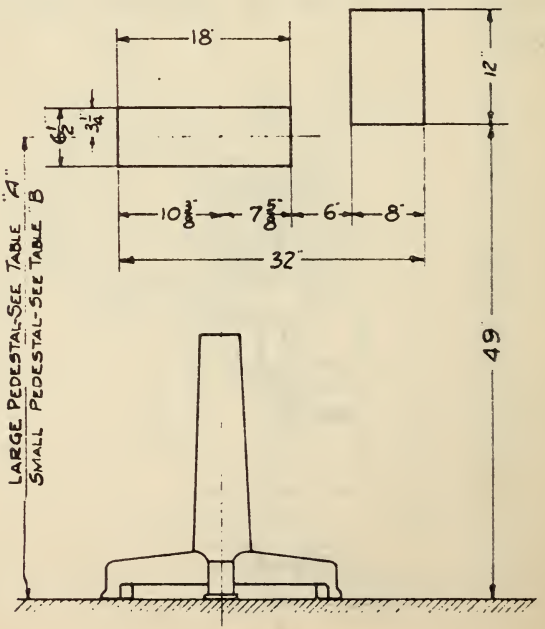


FIG. 224

38. Don't try to get good results with poor carbons.

39. Don't try to get good results with dirty or pitted carbon jaws.

40. Don't remove pins from intermittent sprocket without proper support for sprocket.

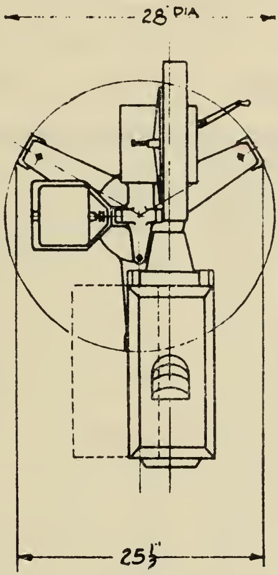


FIG. 225

41. Don't attempt delicate intermittent repairs without proper tools.

42. Don't adjust take-up tension spring too tightly. Too much tension wears sprockets and damages film.

43. Don't run machine with magazine doors open.

44. Don't allow cold air draught from fan or other sources to blow into lamphouse. Such draught will invariably result in condenser breakage.
45. Don't put foreign or homemade attachments of any kind upon machine without consulting the builders.

O Inclination of Projection	*A* Position of Wall Opening	*B* Position of Wall Opening
0°	48″	38¾″
2°	47½″	38¼″
4°	47″	37¾″
6°	46½″	37¼″
8°	46″	36¾″
10°	45½″	36¼″
12°	45″	35¾″
14°	44½″	35¼″
16°	44″	34¾″
18°	43½″	34¼″
20°	43″	33¾″

See Figs. 222, 223, 224, 225

46. Don't screw up condenser rings and holders too much.
47. Don't fail to wash sprocket teeth at least twice a week with stiff bristled tooth brush dipped in kerosene.

48. Don't fail to keep aperture plate clean.
49. Don't fail to keep film loops as small as possible. Large loops are noisy and unnecessary.
50. Don't fail to close lamphouse dowser if film breaks.
51. Don't fail to match "O" marks when replacing gears.
52. Don't fail to remove oil box complete when adjusting intermittent sprocket.
53. Don't fail to keep pad rollers adjusted to one thickness of film.
54. Don't bend the intermittent guide apron. To do so will invite serious film damage.
55. Don't forget to oil the take-up spindle.
56. Don't fail to oil the pad rollers.
57. Don't fail to see that all pad rollers are turning when machine is in action.

BOXED PARTS

In the manufacture of Simplex Parts such as intermittent sprockets, shafts, stars, cams and spindles for same, a policy of finishing these parts on a one ten-thousandth basis is strictly adhered to. This means that these wearing parts are so finished that when an old part is replaced by a new one, the latter will fit perfectly into the worn bearing, thus insuring long life and service.

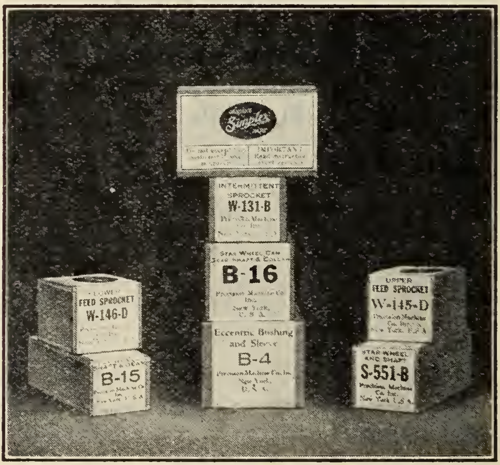


FIG. 226

To insure the user that he is receiving parts that are not only as perfect as the high Simplex standard demands, but are *genuine* Simplex parts as well, a system of sealing and boxing these parts at the factory is carried out.

This system of sealing these parts in containers that are not opened until the user is ready to install them has done much toward discouraging the making of spurious parts by unscrupulous outsiders who have been willing to trade upon the well-known Simplex reputation. Each container not only carries its respective part to the user in its original condition, but it is supplied with a detailed instruction sheet containing explicit and simple directions for installing the part in question.

THE BAIRD PROJECTOR

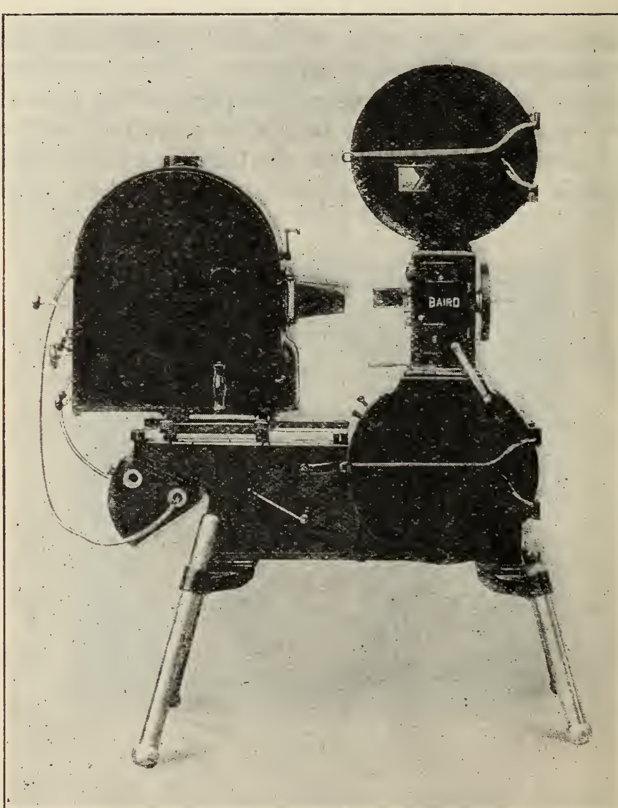


Fig. 227

THE BAIRD PROJECTOR

The Baird Projector has been on the market for a number of years and is daily making new friends.

The mechanism which contains only ten gears is enclosed in four separate fireproof compartments. The motor and take-up mechanism are

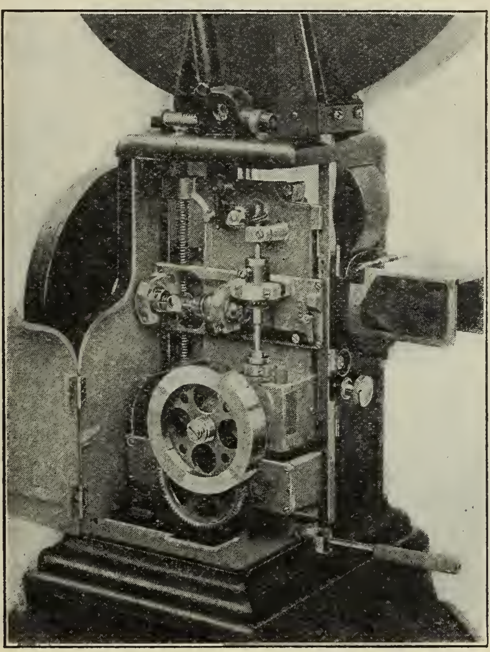


FIG. 228

Gear Side of Mechanism

enclosed in a dustproof compartment. This compartment and the take-up magazine, together with the frame of stand, are cast in one unit. This tends to eliminate vibration.

As will be seen by the accompanying photo-

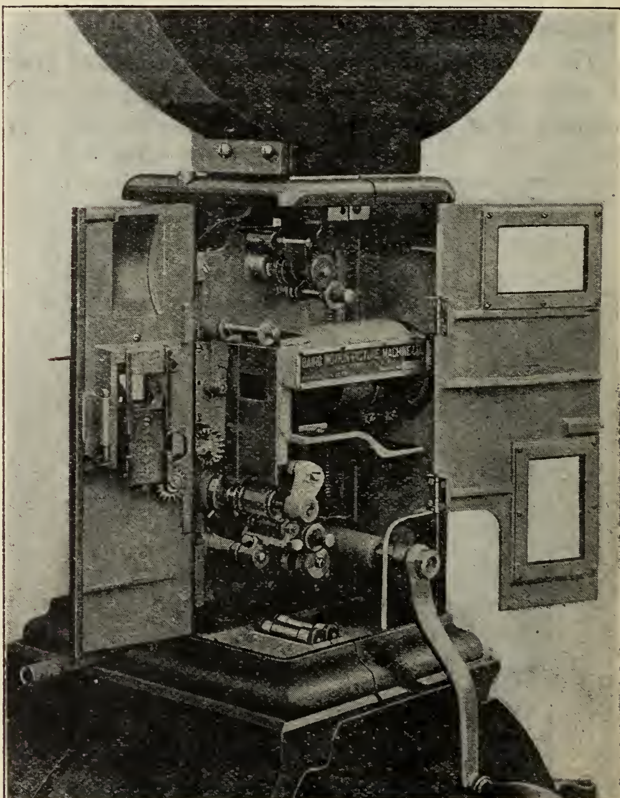


Fig. 229

Detail of Crank Side

graphs, the machine is equipped with three thousand feet magazines.

Adjustment of film tension on the take-up reel is controlled by gravity. The feed reel in the upper magazine is also controlled by a similar device.

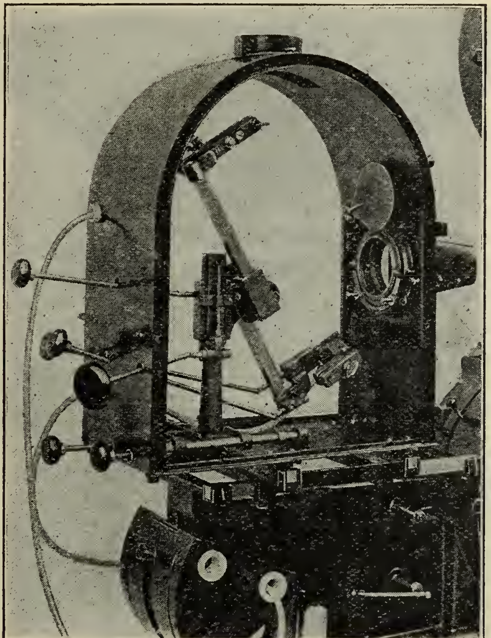


Fig. 230

Lamphouse, Showing Open Construction

The lamp house is of ample proportions. The Baird people were one of the first to recognize the necessity of a large, roomy lamp house. This is built of cast iron and heavy sheet metal. It is

built with an inner and outer wall, with an air space of about three-quarters of an inch between. The two doors form the sides of the lamp house, and when they are open it gives the operator plenty of room to get at the arc-lamp, and it is a very simple matter to get into all corners and so

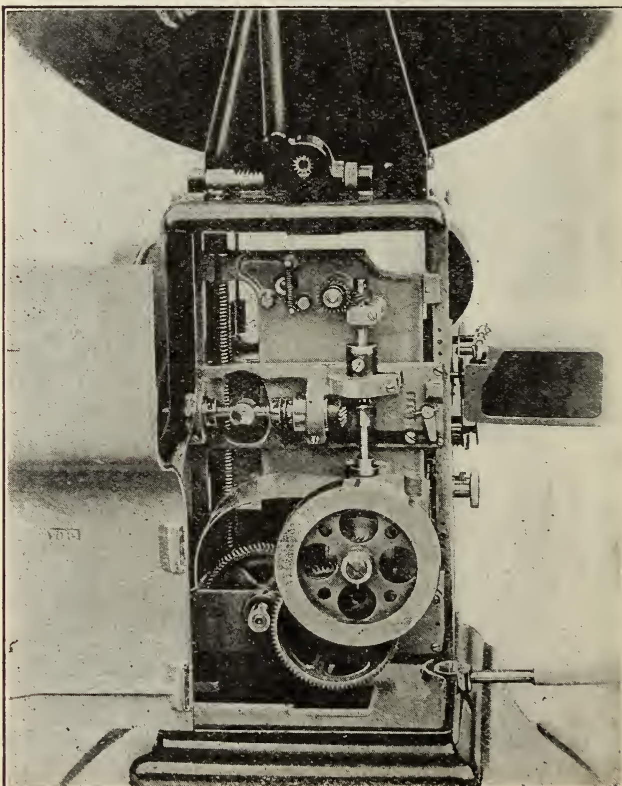


FIG. 231
Detail of Gear Side

get rid of carbon dust, etc. The condenser mound is hinged onto the front of the lamp house and an adjustment for spacing the condensers is provided. The dowser is placed between the arc-lamp and the rear condenser. The arc-lamp is

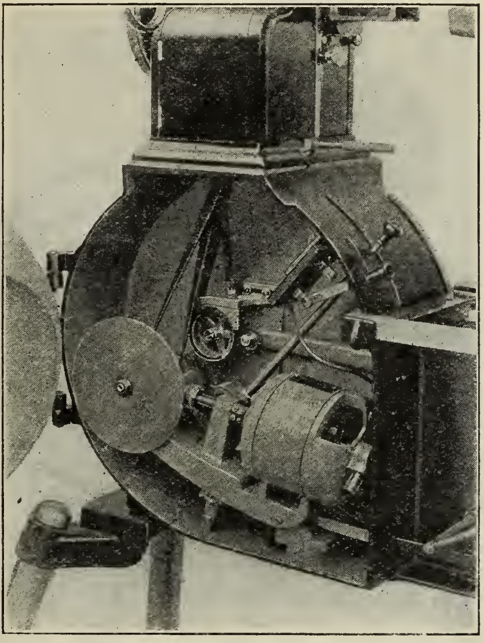


FIG. 232
Detail of Motor Drive

strongly made and allows the operator to trim with a 12-inch carbon in top and an 8-inch carbon in the lower jaw. The intermittent movement is enclosed in an oil casing, which is equipped with an oil level glass, permitting the operator to see

that the movement is at all times well lubricated. It is possible to use either the one to one or the one and a half to one shutter movement. The one to one movement rotates the front shutter shaft at the same rate of speed as the intermittent cam member. The one and a half to one

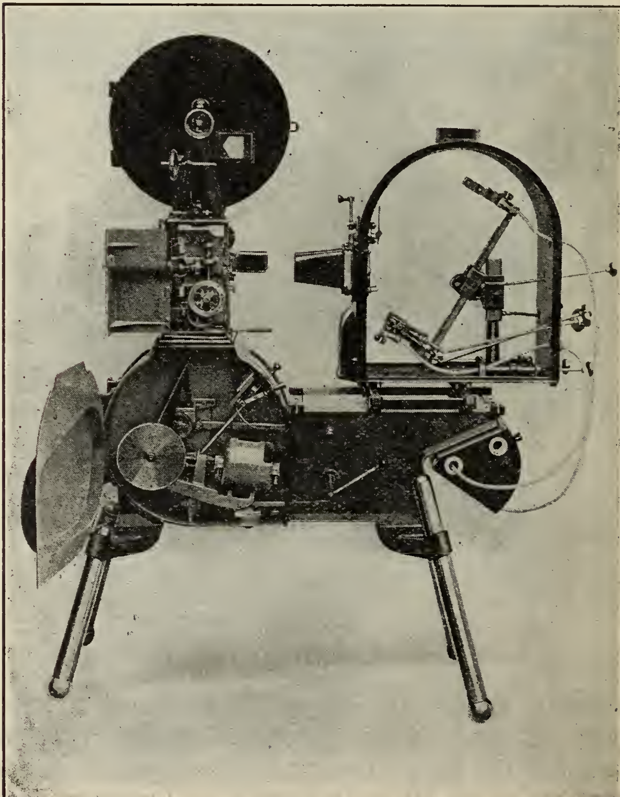


FIG. 233

movement rotates the shaft at one and a half times the rate of speed of the intermittent cam member.

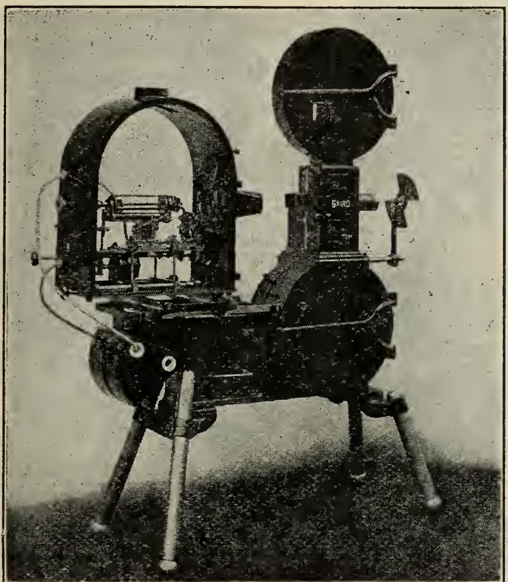


FIG. 234

Equipped with the High Intensity Lamp

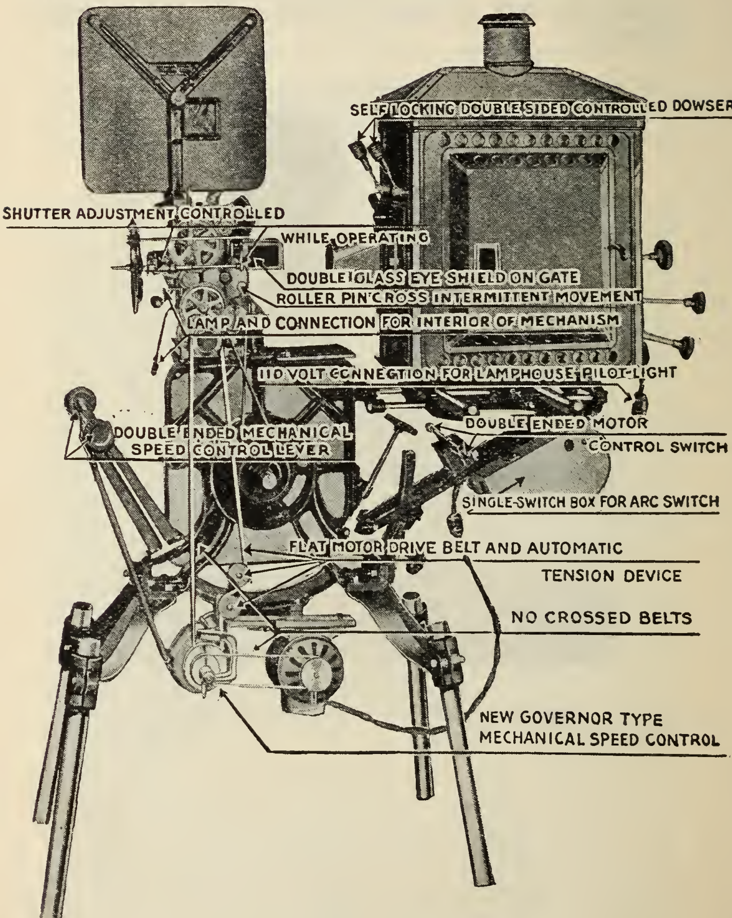


FIG. 214
Powers 6B with Type "E" Lamphouse

POWER'S PROJECTORS

TYP"E" LAMPHOUSE AND LAMP

The Nicholas Power Company have incorporated many new features in the new typ"E" lamp and lamphouse. The proportions of the lamphouse are imposing, the extra large area facilitates an operator in being able to get inside the lamphouse to get at any adjustment of the arc lamp. Two openings in the front of lamphouse allows it to be easily and readily cleaned.

Of paramount importance is the ventilation of the lamphouse, hundreds of dollars are wasted

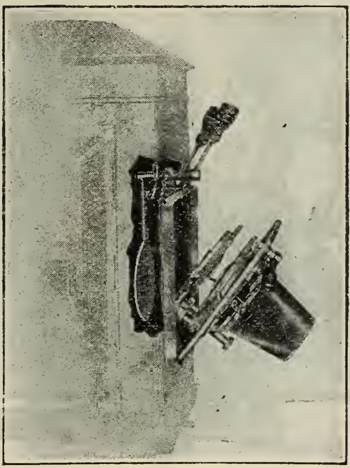


FIG. 236

Close-up of Condenser Mount and Holder, and Adjustment for Inside Dowser

annually in condenser breakage solely on account of poor ventilation in lamphouses.

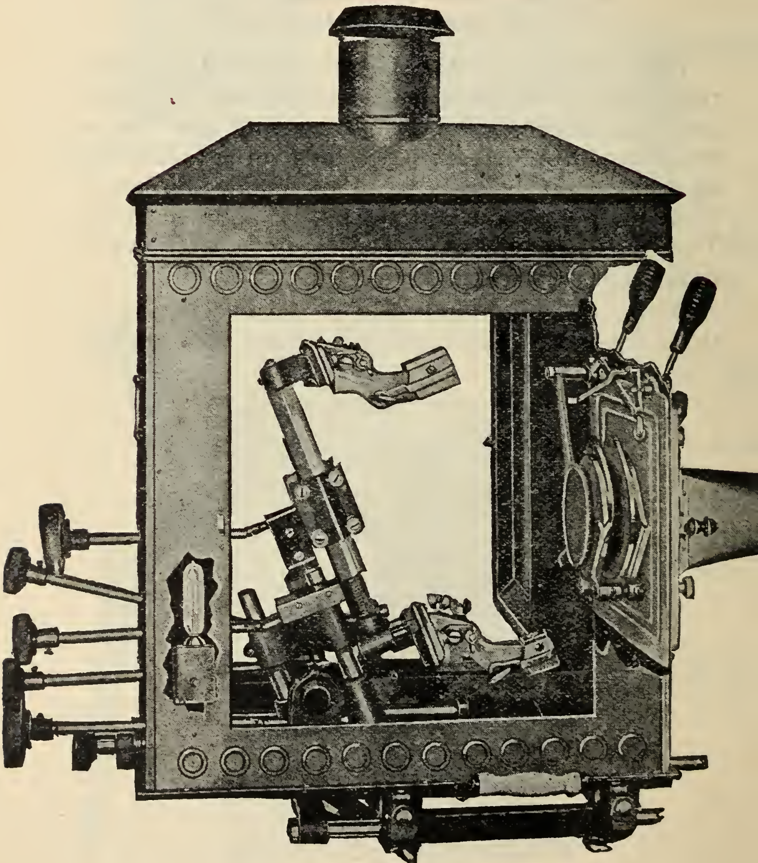


FIG. 237
Type "E" Lamphouse and Lamp
Note—Inside Dowser and Pilot Lamp

The typ"E" lamphouse is so constructed to make the ventilation scientifically correct.

The condenser mount is mounted on a heavy grey iron frame hinged to the lamphouse to open forward, this allows the operator to bring the whole condensing set easily into full view for cleaning, etc. The condenser holders are made of

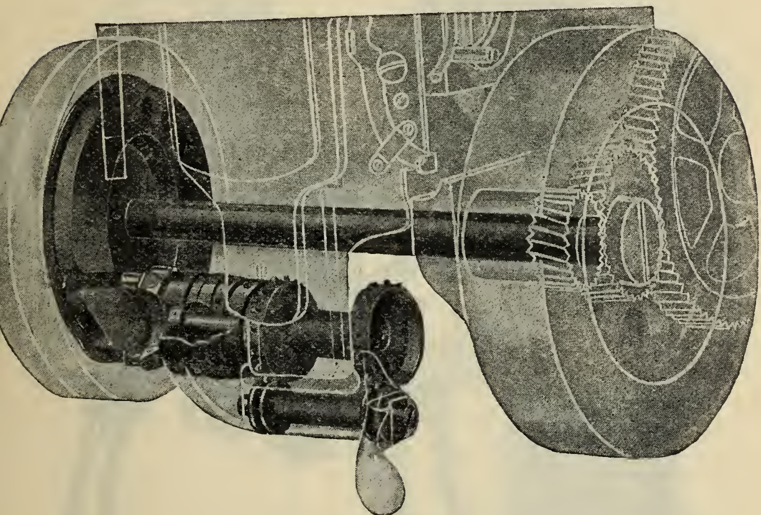


FIG. 238

an extra heavy type of grey iron so constructed that the expansion and contraction of the holders are fairly even and that the heating and cooling off of the condensers is accomplished gradually and evenly, this is a very important point and helps in a great way to overcome condenser breakage.

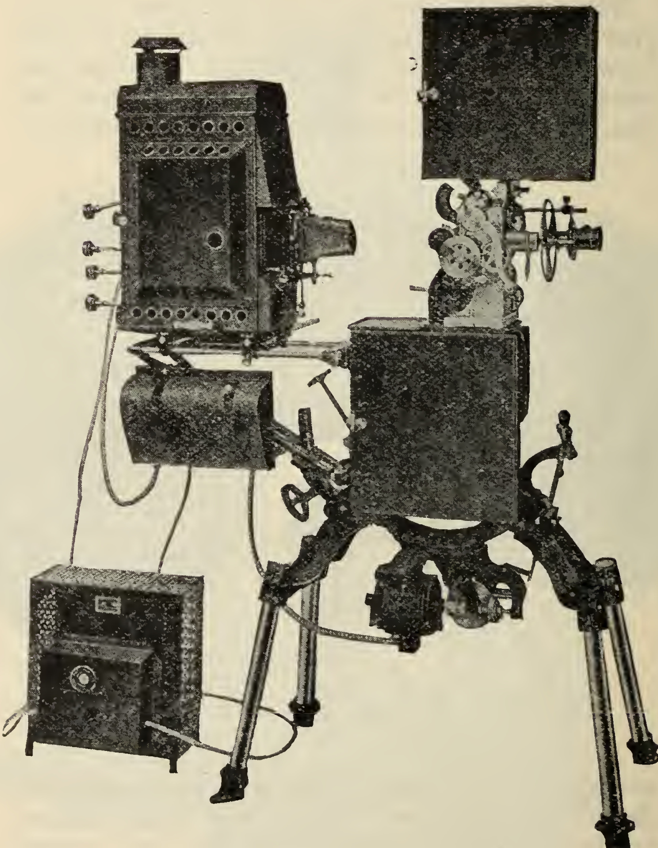


Fig. 239

Power's Cameragraph No. 6B

To assure the condenser proper alignment and hold them securely in place, they are machined with a "V" on two sides, fitting into a "V" groove on the mount. Placed directly under the condenser mount is an adjustment which controls the back condenser (one nearest the arc) allowing

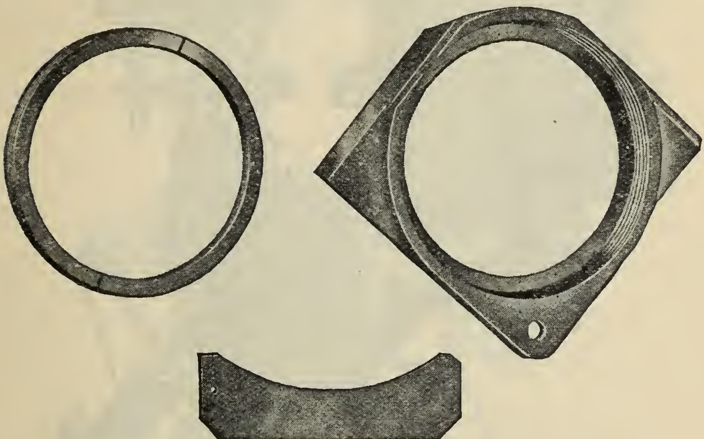


FIG. 240
Condenser Holder, Ring and Key

the operator to space his condensers to the exact focal distance.

The lamphouse is equipped with an inside dowser to protect the condensers from the heat of the arc while the operator is "forming a crater," etc., the dowser handle is placed on front of the lamphouse directly above the condenser mount locking adjustment. Radical changes have been made in the arc lamp, it is built heavy enough to

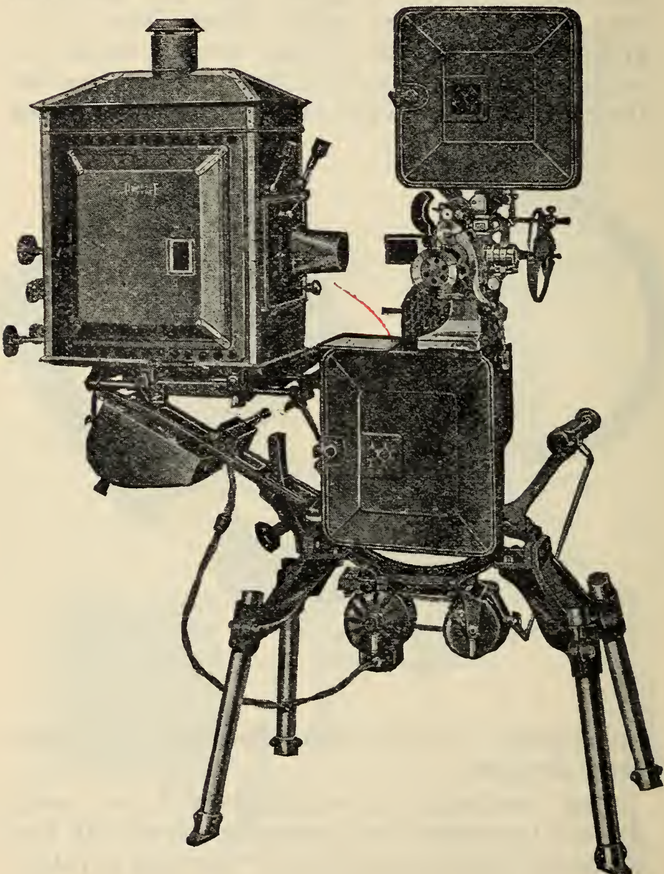


FIG. 241
6B with Type "E" Lamphouse
Operating Side

take care of any amount of current up to 150 amperes; the features of the lamp are as follows:

1—Upper carbon holder designed to take from $5/8$ to $1\frac{1}{8}$-inch carbon. Lower carbon holder 5/16-inch to $5/8$-inch carbons, manufactured with the "V" type, assuring a rigid hold on the carbons without breaking them.

2—Both upper and lower carbon holders are equipped with a clamp which is to take the place

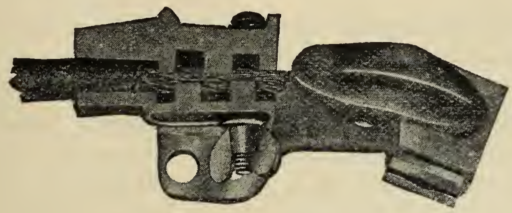


Fig. 242
Cross Section of Carbon Holder, Showing Position of Wire in Interlocking Corrugations

of lugs for the wires. These clamps have been so manufactured of a series of interlocking corrugations on both top and bottom of clamp so that when wires have been clamped between them, they will have a positive hold. To take care of any possible arcing, the clamp and the carbon holder have been manufactured of one piece.

3—Another feature of the lamp is the fact that the lateral and backward and forward adjustments are made on the lower part of the lamp so that on adjusting the carbons, it will not change the position of the crater of the upper carbon.

4—The fact that the raising and lowering of the lamp is done by means of a worm wheel and gear, gives the lamp additional rigidity.

5—Square steel bars held with a spring cover have been used in the manufacture of back rods, to take care of any expansion and giving same a greater wearing surface.

POWER'S "6B" STAND

The stand, which is exactly the same for all "6B" models, is exceptionally substantial and entirely original in design. The "6B" base is made in two sections, the lower part with its four legs of solid construction setting in sockets which can be attached to the floor. The motor drive is solidly bolted to the underside of the lower section and remains horizontal.

The upper section carries the mechanism, magazines and lamphouse, and this section is designed to permit tilting in a vertical plane to get the necessary angle from the projection room to screen. By means of heavy bolts passing through slots, both sections are securely held to give positive rigidity once the proper angle is secured. A very fine and accurate angular adjustment is obtained by means of a worm thread. The adjustment is also very accessible and permits centering of the picture on the screen during operations. This is a highly important feature of "6B" models.

The upper magazine is equipped with a newly designed revolving spindle upon which the reel is held by a key. A simple friction device prevents the reel from revolving through its own momentum, thus maintaining an even tension on the film at all times.

The double switch box supplied on earlier models of Power's projector has been discontinued. In its place a separate motor switch has been installed which may be controlled from either

side of the machine. The arc switch is now mounted directly underneath the lamphouse so that it may be operated from either side of the machine.

The motor speed control lever furnished with all motors is double ended on all machines supplied with mechanical speed controls and is also accessible from either side of the projector. The old style round motor drive belt has been replaced with a $5/8''$ flat endless belt. When it becomes

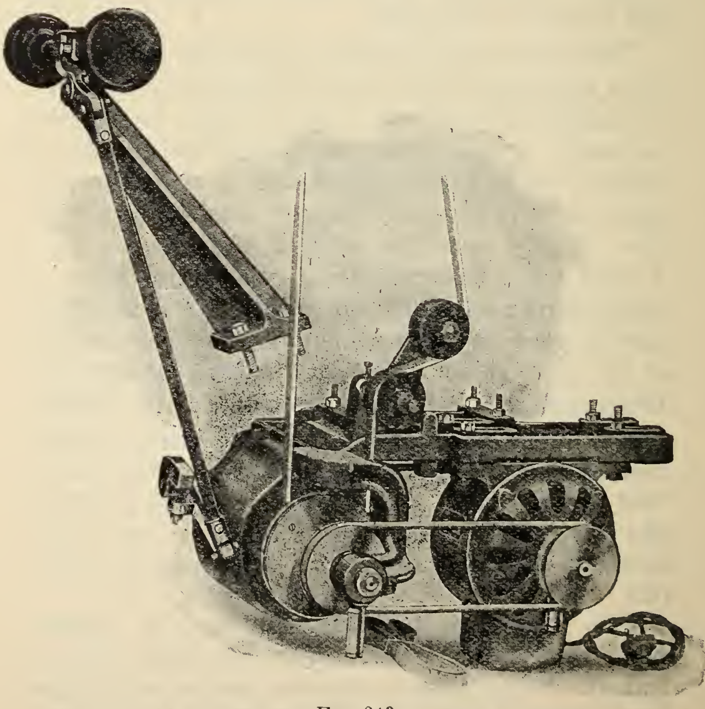


FIG. 243
Double Ended Speed Control

necessary to tilt the machine, the slack from this belt is taken up by means of an automatic belt tightening device attached to the governor type speed control base on the improved projector and to the stand on the regular model. Details of the mechanical speed control will be found on page 641.

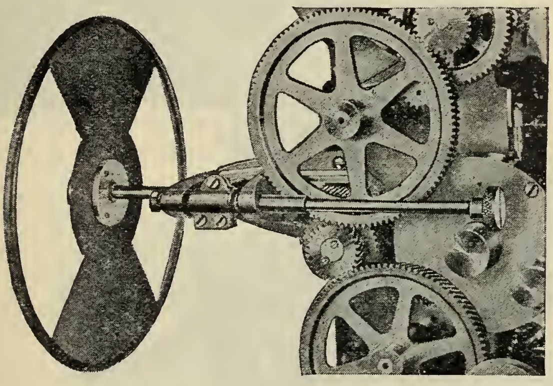


FIG. 244
Shutter Adjustment

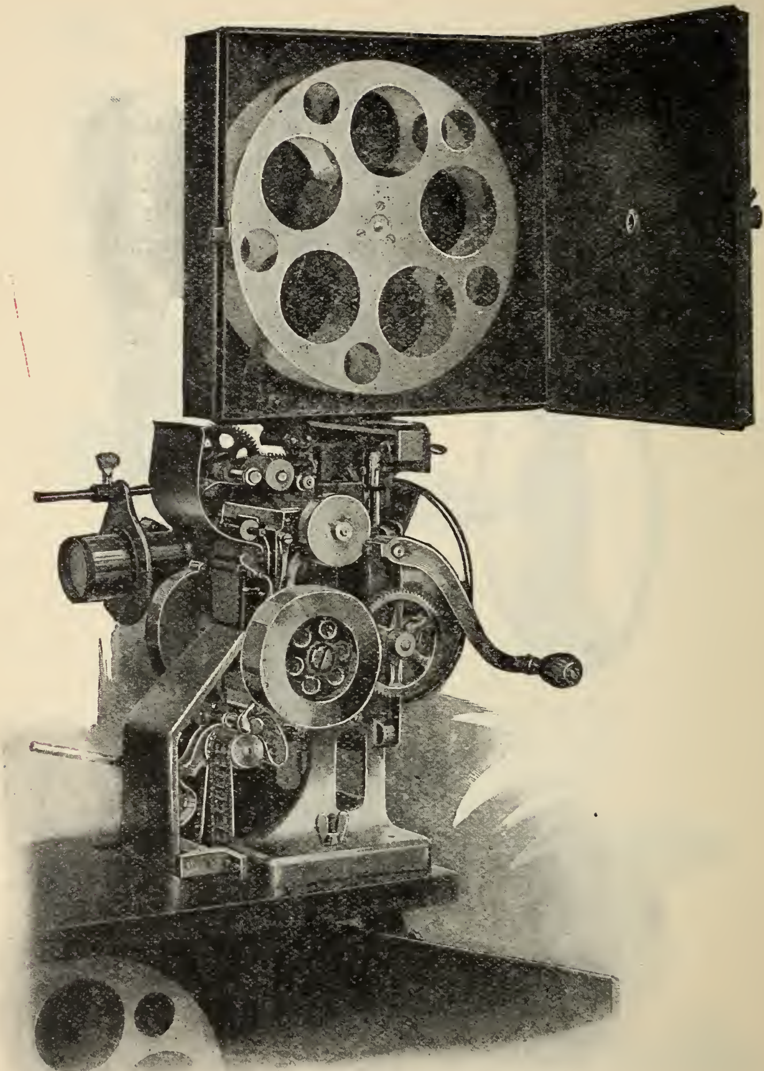


FIG. 245

Power's Cameragraph No. 6A, Showing Film Threaded Through Machine

AUTOMATIC SHUTTER

The shutter covering the aperture in gate of machine and controlled by the centrifugal movement. It is so arranged that the shutter will be held up by centrifugal force as long as the machine is in motion, but should the machine stop for any reason then the shutter falls and cuts off the light

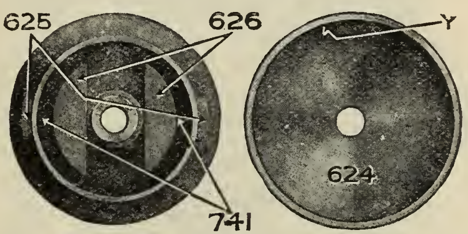


Fig. 246
The Centrifugal Movement with Cover Removed

from film. It is a fire prevention device. Should the automatic shutter refuse to work and same cannot be remedied by oiling, it will then be necessary to take the cover off the centrifugal movement 624 Fig. 246, then examine springs and shoes 741 Fig. 246, and see if the shoe track *Y* Fig. 246 is not scratched.

WORKING OPERATION OF POWER'S LOOP-SETTER

The illustration shows a strip of film forming the lower loop around roller (A). When the loop is lost (drawn taut), the roller is necessarily elevated, thus causing a slight rotary motion in cylinder (B). A diagonal slot in this cylinder, in contact with a pin fastened to arm (E), causes

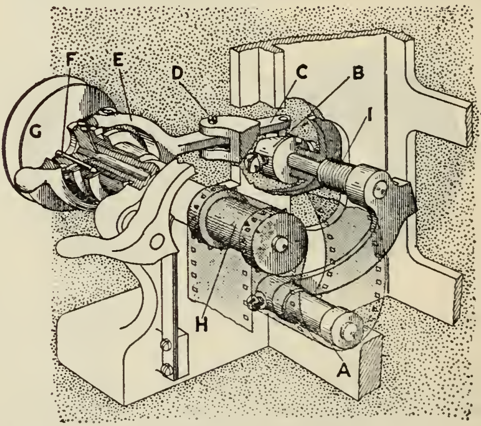


FIG. 247
Power's Automatic Loop-Setter

the arm to move outward; but as arm (C) operates as a lever, with its fulcrum at point (D), the other end of the arm at (E) moves inward, thus disengaging pin (F) from the driving pulley (G). This breaks the connection whereby motion

is transmitted to take-up sprocket (H), and the sprocket stops revolving. The loop reforms instantly, and roller (A) is forced back into its original position by coil spring (I). Pin (F) immediately re-engages with driving pulley (G), and the take-up sprocket (H) starts to revolve again as a natural consequence. The whole train of operation is automatic—its results instantaneous.

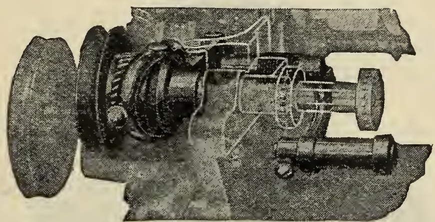


FIG. 248
Automatic Loop-Setter

POWER'S BALL BEARING TAKE-UP

The importance of the take-up device should not be overlooked as its primary function is to make proper compensation for the ever-changing size of the film as it winds up on the reel in the lower magazine. Power's ball bearing take-up has been a part of Power's projectors for a number of years and has proven absolutely dependable and efficient.

The take-up consists primarily of two friction discs, which are held in contact by means of a spring. One of these discs is faced with fibre, which assures an excellent frictional contact. The driving disc (a), is left free to revolve around take-up spindle (b), as an axis. The driven disc

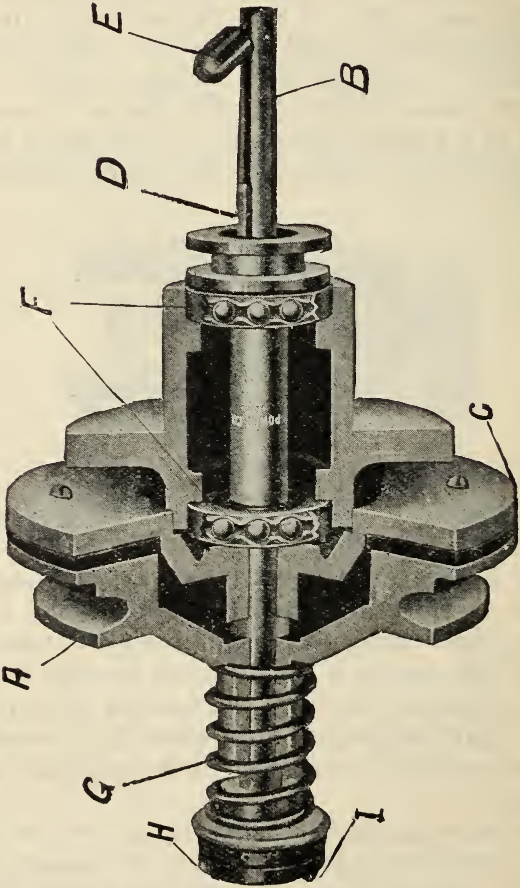


Fig. 249
Power's Take-up

(c) is fastened to spindle (b). By frictional contact, motion is transmitted from disc (a) to disc (c), and thus spindle (b) is caused to revolve also. The take-up reel fastens to spindle (b) at (d). The reel is held firmly on the spindle by means of catch (e). When the catch is in a horizontal position, it is in exact line with spindle (b), thus making it very easy to put the reel on, or take it off the spindle. Spindle (b) runs in ball

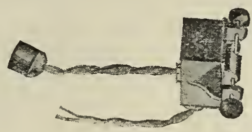


FIG. 250

bearings (f), which eliminate all unnecessary friction in operation.

As the film winds on the reel, the steadily increasing load gradually retards the speed at which disc (c) revolves, and this automatically regulates the revolutions of the take-up reel, so that at every movement the proper tension on the film is assured.

The friction between discs (a) and (c) may be adjusted by increasing or decreasing the tension on spring (g). This may be accomplished by simply giving a few turns in either direction, to collar (h), which is threaded on the end of spindle (b). When the desired tension has been secured, the collar may be locked in place by means of set screw (i).

Prior to the introduction of Power's mechanical speed control, great difficulty had been found in

keeping oil from reaching the parts of the control. It is not necessary, however, to keep oil from reaching parts of Power's governor type mechanical speed control as it will operate just as efficiently when bathed in oil as when dry; in fact, a little oil between the discs will be found beneficial.

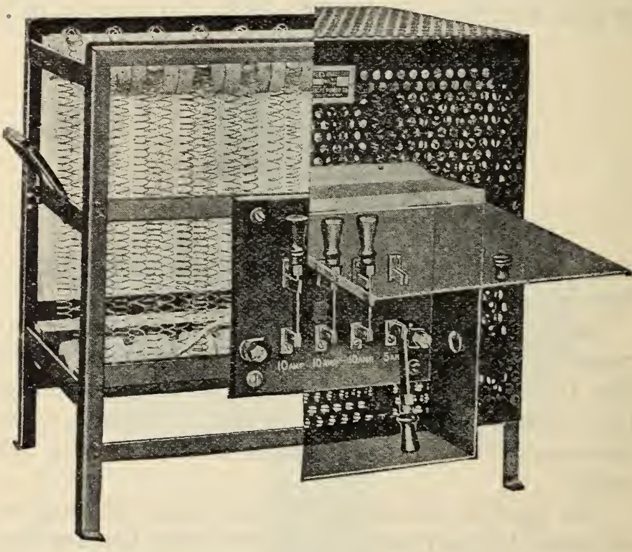


FIG. 251
Power's Multiple Unit Rheostat

THE INTERMITTENT MOVEMENT PRELIMINARY REMARKS

The moving picture is accomplished by flashing a great number of stationary photographic views before the eye in such rapid succession that the eye is deceived into the *belief* of having beheld actual motion.

The photographic views, which are usually taken at the rate of sixteen per second, are printed in direct succession upon a ribbon of *transparent* film one and three-eighths inch in width and between one and two thousand feet in length. Each view is condensed into a rectangular space approximately one inch wide and three-fourths inch high.

When the film is run through the projector at normal speed, sixteen of these views are shown each second. It would appear from this that each view is shown for one-sixteenth of a second. Such is not the case, however. Each view is held stationary before the lens for only a *part* of this minute period of time, and the *remainder* of the period is consumed while the film is being moved down a distance of three-fourths of an inch, so as to bring the succeeding view in line with the lens.

During every such movement of the film, the main blade (or wing) of a revolving shutter, passes in front of the lens, thus preventing any trace of the movements from reaching the screen. If this were not done, the picture would be greatly marred by streaks of light known as "travel ghost." An additional wing (and sometimes two)

is inserted in the shutter wheel for the purpose of doing what is technically known as "equalizing the light." We will not discuss this matter of light equalization, as it has no direct bearing upon the point that we wish to bring out.

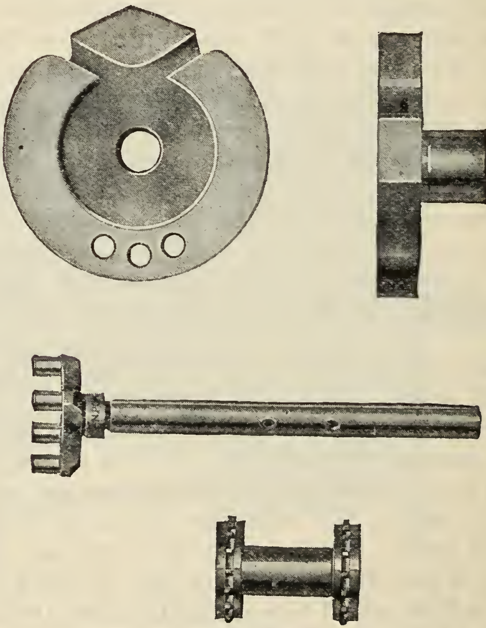


FIG. 252

It is the necessary passage of these wings in front of the lens that prevents an attainment equalling theoretical perfection wherein each view would appear on the screen for its entire allotment of one-sixteenth of a second without interruption of any kind.

It would probably be possible to devise a way to move the film so rapidly that the eye could not perceive any trace of the movement, and thus the necessity of using the revolving shutter would be eliminated, but we are prevented from doing this

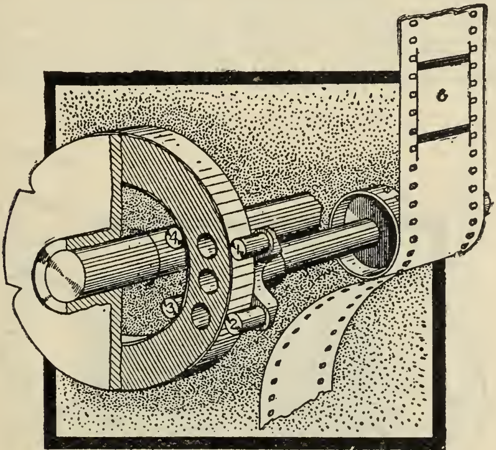


Fig. 253

by the very important fact that wear and tear on the film must be taken into consideration. The movement of the film must not be made so rapidly nor in such a jerky manner as to cause the film to rip or pull apart.

TECHNICAL DESCRIPTION OF THE INTERMITTENT MOVEMENT

The term "intermittent movement" is used to designate that part of the mechanism of a moving picture projector, which performs the important function of stopping the film at regular intervals,

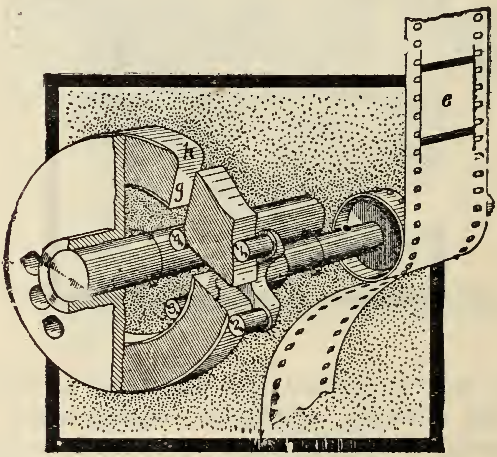


FIG. 254

so that the photographic views may be successively held in line with the lens.

This movement consists primarily of four elements, namely: a diamond shaped cam, a locking ring, a pin cross and a sprocket. Photographic views of these parts will be found on page 622.

The cam and locking ring are formed together

on the face of a solid steel disc. The four pins of the pin cross are formed from the end of a solid cylinder of steel. The remainder of this cylinder is turned down to the proper diameter to act as a spindle upon which the sprocket is securely fastened. The sprocket has two rows of teeth to mesh with the holes that are perforated on each side of the film.

Figures 253, 254, 255, and 256 show these ele-

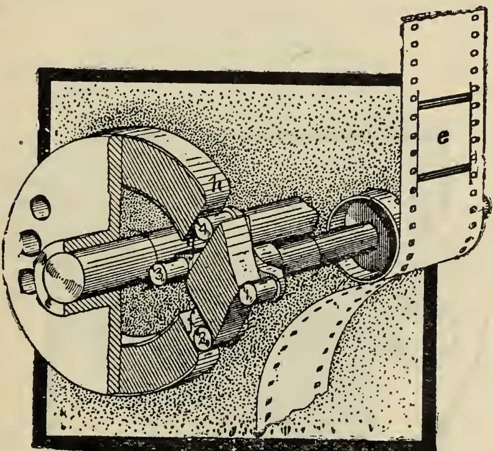


FIG. 255

ments in action. A portion of the back of the cam-ring disc has been cut away so as to expose the workings of the movement during one revolution of the disc. The curved arrows indicate the direction in which the parts are revolving. The sprocket is in mesh with a short strip of film. Portion *e* of this film, which lies between the heavy black cross lines, represents one of the

photographic views to be projected upon the screen.

In Figure 253, the four pins of the pin cross are shown in engagement with the locking ring. Pins 1 and 2 are at the outer circumference and pins 3 and 4 are at the inner circumference of the ring. Although the ring is revolving, it cannot impart motion to the pin cross, as the pins are securely locked by contact with the inner and outer surfaces of the ring; consequently the pin cross, the

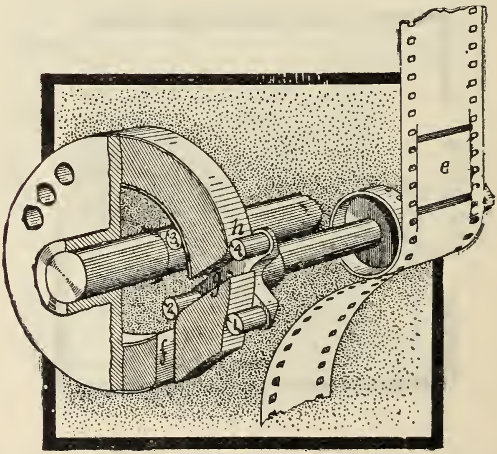


Fig. 256

sprocket and the film are at rest. It is during this period of rest that the photographic view is being projected on the screen.

In Figure 254, the pins are disengaging from the locking ring. The cam is just starting to engage with pin 1. As the engagement takes place the

pin is pushed forward and upward, thus imparting a rotary motion to the pin cross spindle. The sprocket, being fastened to this spindle rotates with it, thus pulling the film downward.

In Figure 255, pin 1 has almost reached the apex of the cam. Pin 2 is traveling into slot *f*, pin 3 is describing an arc in the space between the ends of the locking ring, and pin 4 is traveling out of

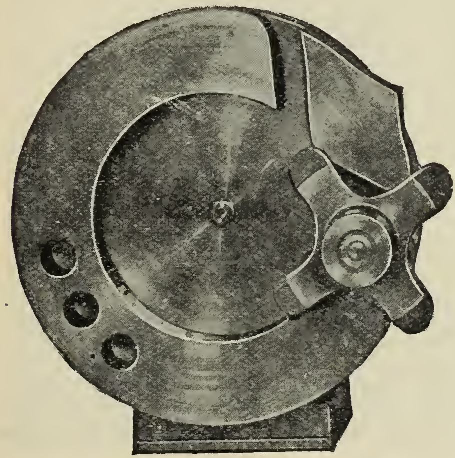


FIG. 257

slot *g*. As pin 1 slides over the apex of the cam, pin 4 engages with curved surface *h* at the end of the locking ring, and the pin is thrown forward and upward until it slides on to the outer surface of the locking ring.

In Figure 256, pin 4 has just reached the outer surface of the ring. The four pins are immediately

locked as the locking ring travels into the space between them. In contrast to the pin position in Figure 253, pins 1 and 4 are now at the outer circumference and pins 2 and 3 are at the inner circumference of the locking ring. It can readily be seen that the pin cross spindle has made a quarter revolution, and that view *e* has been drawn downward a corresponding distance.

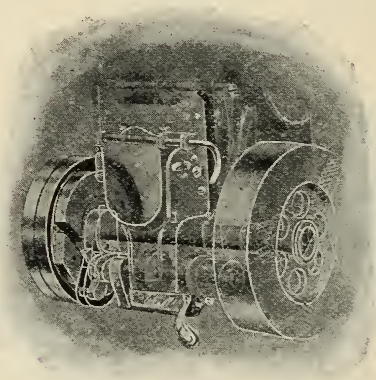


FIG. 258
Intermittent Movement with Oil-Tight Casing

Bear in mind that these pins can only move in the path of a circle. As pins 2 and 4 travel through their respective slots it would appear to the uninitiated mind as though the pins must travel in a straight line. This is not the case, however. The fact that the cam-ring disc is revolving, constantly changes the position of these slots so that their straight lines intersect the circular path of the pins at successively different points.

One great advantage that this particular movement has to offer, may be demonstrated by making the following simple experiment:

Tie a one foot length of ordinary cotton thread to a piece of metal weighing slightly over one pound. Take the untied end of the thread between the fingers and by an upward pull, endeavor to

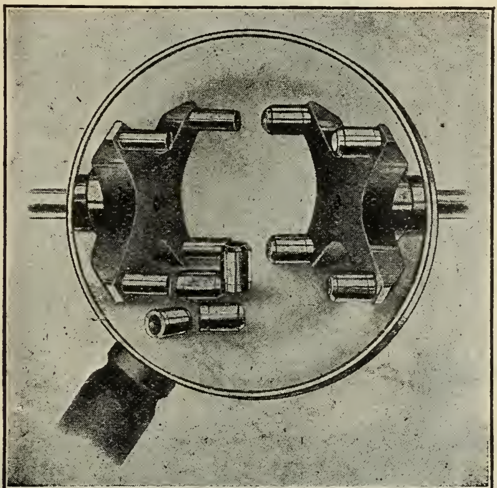


FIG. 259
A Magnified View of the Pin Cross of the Power's Machine with and without Roller Bearings in Place

lift the piece of metal a distance of one foot in the shortest possible time. A sudden jerk will snap the thread. A slow upward pull will allow the thread to stand the strain of the weight, but considerable time is consumed in lifting the metal. If the slow pull is exerted until the metal has

started to move, the pull may then be steadily increased, and consequently the metal can be lifted much more quickly.

This analogy may be applied to the star and

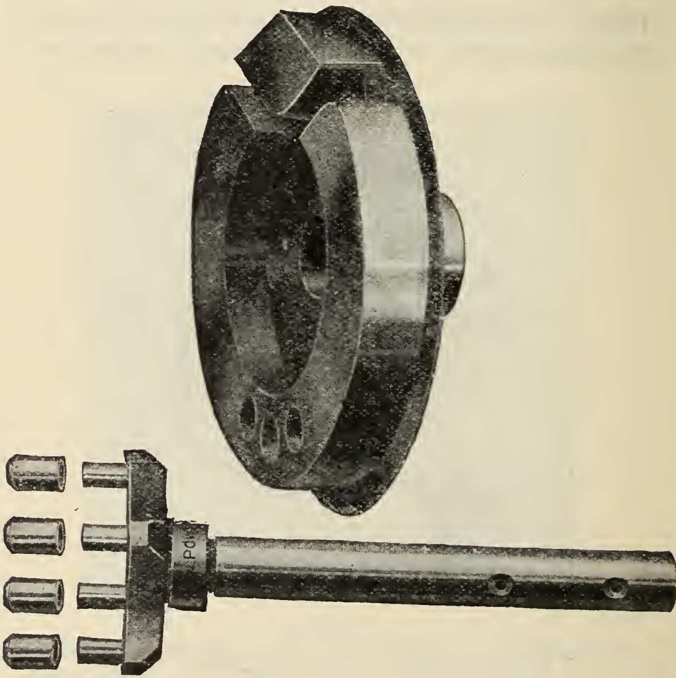


Fig. 260

Detailed Views of the New Movement, Showing the Cam with the Disc Which Holds the Roller Bearings in Place, and the Pin Cross with Bearings Removed

cam intermittent movement, which has been carefully designed, to move the film downward, by starting the motion with a scarcely perceptible pull that steadily increases to a maximum as pin 1

(Figure 255) slides over the apex of the cam, after which it decreases in the same steady manner until the pins are locked by the ring, and the film is again at rest. Not a moment of time is lost, and yet the film is moved so easily that the wear and tear is reduced to a minimum.

The elements of the intermittent movement are made from carefully selected tungsten-chromium steel, which is very tough and durable. The most delicate instruments are used in measuring the dimensions of the elements, one ten-thousandth of an inch plus or minus being the limit of permissible variation.

The cam and pin cross are enclosed in an oil-tight casing. An oil cup is fastened to this casing, and by keeping the parts plentifully supplied with a high grade machine oil, a practically noiseless operation of the movement without perceptible wear on the parts, is insured.

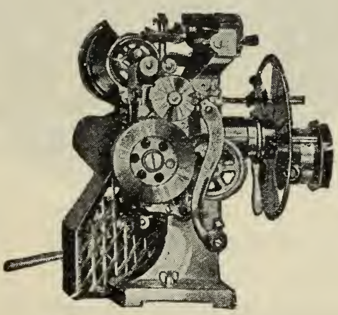


FIG. 261

POWER'S SPEED INDICATOR

A scientifically designed and accurately constructed instrument which shows at a glance the speed at which the projector is operating and the

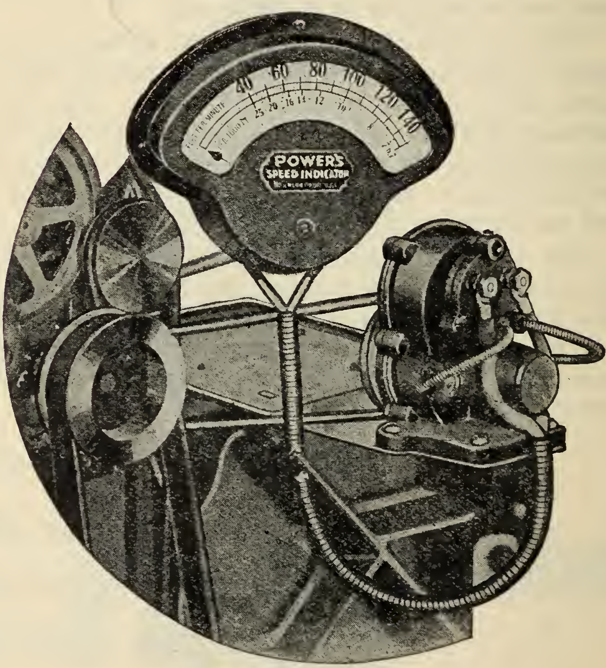


FIG. 262
Power's Speed Indicator

exact film footage passing through the machine in a given time.

Indicators may be placed at any number of points desired, and the musical director and pro-

jectionist will have no trouble in closely following the program and time schedule.

Power's speed indicator equipment consists of a high-grade magneto generator which is connected by suitable wiring with one or more exceedingly accurate indicating instruments having scales, celebrated, to show the speed of the film in feet per minute and minutes per thousand feet. Other types of scales will be supplied at a slight additional cost. The generator is driven by belt from the motor attachment pulley on the mechanism.

NUPOWER MOTOR

This motor, furnished exclusively with Power's projectors, is a new departure in motor design, and has a number of special features which make its use highly advisable under certain conditions. The Nupower is a universal motor and can be used on D.C. or any cycle A.C. It is therefore particularly adapted for installations in small towns or outlying districts where unusual current conditions would otherwise require specially designed motors.

The Nupower motor has a very wide range of speed variation, and excellent speed control is secured through the use of an adjustable rheostat having a large number of contact points. This motor has been thoroughly tested under varying conditions and is strongly recommended for use where the current available is not suited to the regular motor furnished with other types of speed control.

POWER'S PIN CROSS ROLLERS

This is an exclusive feature on Power's projectors and is one of the most important and successful improvements made on motion picture projectors in recent years. Power's pin cross rollers are small, movable sleeves which fit over the pins of the pin cross, and, acting as a roller bearing, re-

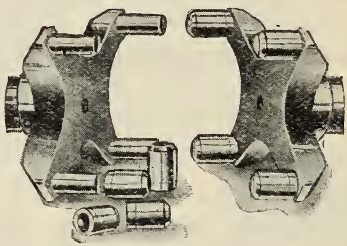


FIG. 263
Pin Cross Rollers

duce frictional wear and noise to a minimum. The pin cross rollers are made of specially selected steel, hardened and finished with the utmost care.

If the intermittent movement is given proper attention at regular intervals, it should give excellent service for at least a year, and we have known instances where intermittents have given splendid results after two years' operation.

When an intermittent movement leaves the factory it is set up as close as practical but after being in use for about two weeks the intermittent pin cross should be set up close against the outside of the cam ring. This is done by turning the large eccentric bushing—UP A TRIFLE—*never*

down. After this no further adjustment is necessary for a period of several months, when the pin cross should be again set up against the cam ring.

The cam and pin cross are enclosed in an oil-tight casing. An oil cup is fastened to this casing, and by keeping the parts plentifully supplied with a high-grade lubricant, a practically noiseless operation of the movement without perceptible wear on the parts is assured.

POWER'S INSTRUMENT PANEL

One of these panels, mounted on the wall in front of each projector will enable the projectionist to carefully watch the current and voltage regulation of the arc and the speed of the mechanism.

The equipment consists of a nicely finished black slate panel, a metal panel box, one voltmeter reading arc voltage and one ammeter reading to 150 amperes. Space is provided in each panel for one speed indicating instrument as described under "Power's Speed Indicator." A special automatic relay is also provided inside the panel box which automatically opens the voltmeter circuit when the arc is not burning. This device allows the use of a lower scale voltmeter which permits more accurate readings of arc voltages when the arc is burning. High grade Weston instruments are supplied with this equipment.

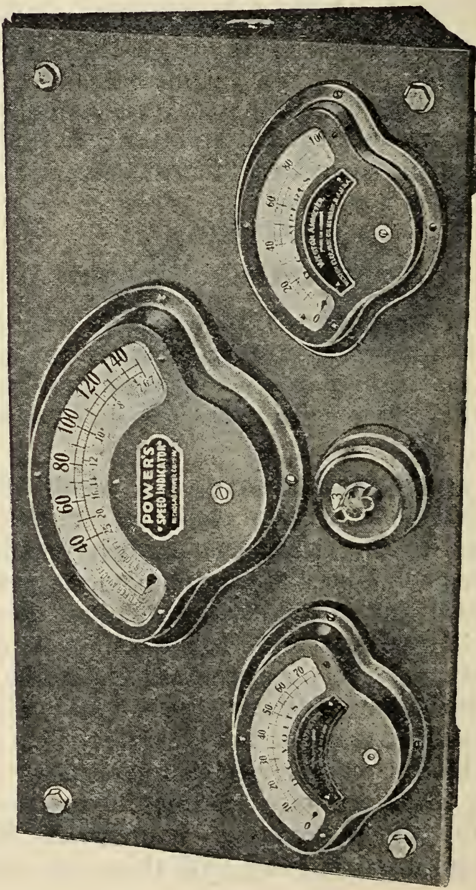


FIG. 264

POWER'S GOVERNOR TYPE MECHANICAL SPEED CONTROL

The application of the governor principle to speed control is an important mechanical advance and Power's governor type mechanical speea control has eliminated several serious troubles heretofore found in speed controls. Absolute accuracy and dependability are secured.

By setting the lever of Power's governor type mechanical speed control and then simply throwing in the motor switch, the projector will at once reach the exact speed for which the control is adjusted. If Power's speed indicator is used in connection with the new control, all difficulty regarding the proper timing of the picture is eliminated. By referring to the dial of the indicator and making the necessary adjustment to the regulator of the control, the picture may be projected at so many feet per minute and a given number of minutes per thousand feet to be consumed.

All moving parts revolve upon one common shaft which in turn is free to rotate in its bearings so that the least possible amount of friction is present in any part of the apparatus. Another important feature of this control will prove of great value to communities troubled with fluctuating voltage as a considerable drop of line voltage does not affect the speed of the mechanism even though the motor would, under these conditions, slow down considerably.

GOVERNOR TYPE MECHANICAL SPEED CONTROL

The action of Power's governor type speed control will be more clearly understood by referring to the lettered drawing, Fig. 265.

The pulley A is belted directly to the motor shaft and is therefore constantly rotated at full maxi-

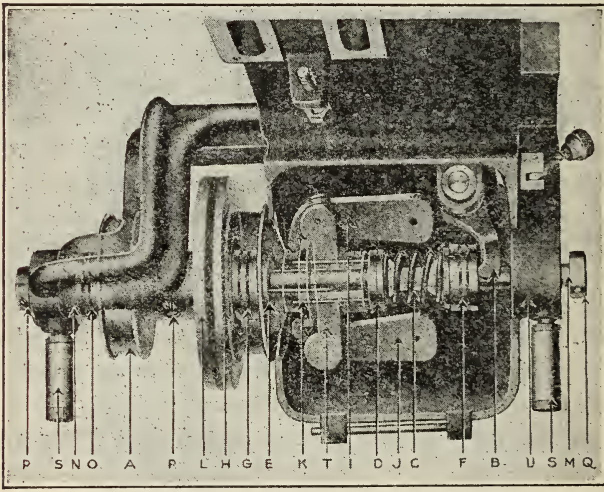


Fig. 265

mum speed when motor switch is closed. If there is no tension applied to the control lever the balance of the apparatus will remain stationary. If, however, the control lever is so adjusted as to apply pressure to compression fork B the tension spring C will apply pressure through thrust bearing F and coupling fork D to disc H, bringing discs L and H into tight contact with each other.

The instant this contact is formed the entire control will begin to revolve and governor weights I J will be thrown outward, thereby causing a slight additional pressure on tension spring C applied from point K which tends to separate discs H L. It is this counter pressure which permits the variation in speed between these two discs, and the greater the pressure applied at B the faster will the entire control operate, up to the point where the governor ceases to exert any counter-pressure against fork B, at which time the driving element A and the driven elements H, E, K, I, J, D and C will all operate at maximum speed.

All moving parts are free to rotate on shaft M, and excessive friction on bearing N is prevented by thrust bearing O. End thrust between disc L and coupling fork E is reduced to a minimum by thrust bearing G.

The entire control is readily dissembled by removing either collar P or Q, when the shaft may be pulled out from either end and the moving parts caught in the hand.

FILM FOOTAGE RECORDER

The recorder can be attached on the crank-side of any "6A" or "6B" mechanism, and when in position, engages directly with the crank shaft, thereby accurately registering every foot of film that passes through the projector. If an accurate

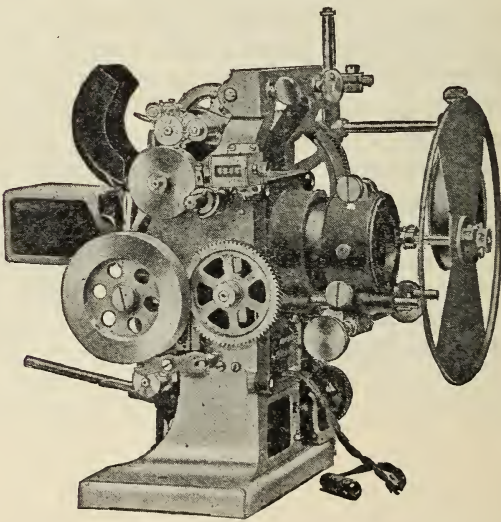


FIG. 266
Head of 6B, Showing Film Footage Recorder

footage record is taken when the film is first run, the projectionist will then know to the foot exactly how much film is left upon the upper reel at any time and can arrange accordingly for the change-over.

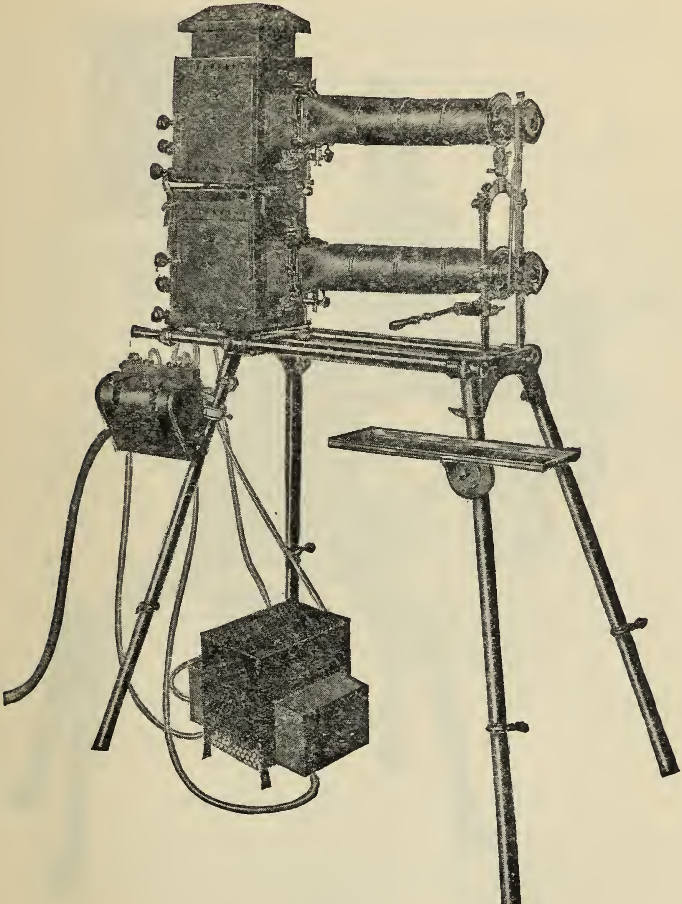


FIG. 267
Power's Stereopticon

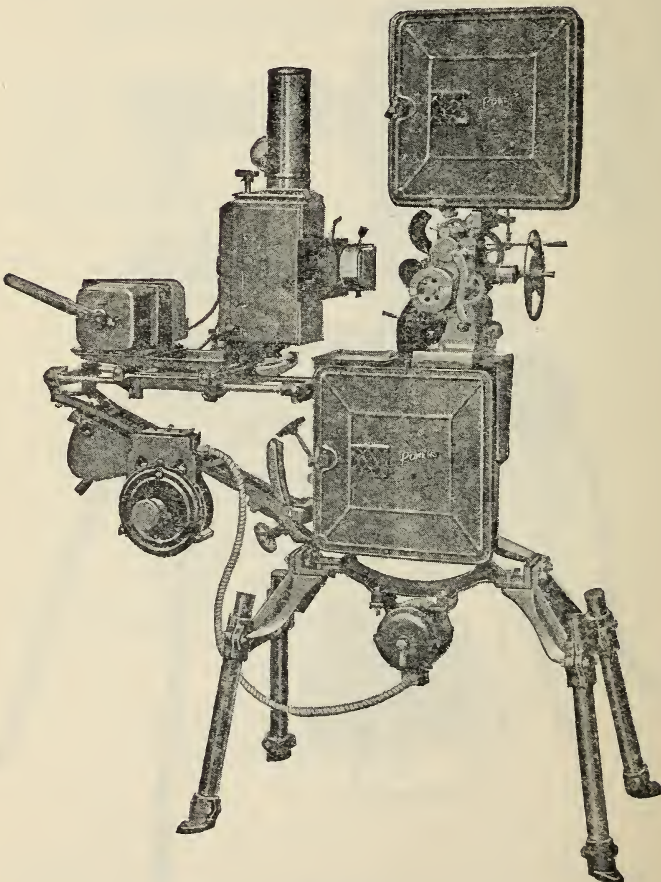


Fig. 268
Power's 6B Mazda Equipment

POWER'S "G-E" INCANDESCENT EQUIPMENT

This is a splendid equipment for all theaters having a maximum main floor seating capacity of not more than one thousand, a picture not over fourteen feet wide and a throw not exceeding ninety feet. It is the most recent development of the General Electric Co. for Mazda and other incandescent lamps for motion picture projection, and under proper conditions it is an unqualified success.

Incandescent illumination, in addition to other advantages, has a soft, pleasing tone which brings up the depth of the picture and the rendition of colors is very satisfactory.

Although the incandescent equipment demands the care of an experienced projectionist, its operation is comparatively simple and it is therefore strongly recommended for use in schools, churches and auditoriums. Another consideration of great importance is the relatively low amperage used on the incandescent equipment which avoids the necessity for heavy wiring.

POWER'S TYPE "E" SPOTLIGHT

A compensating balancing device secures perfect balance, regardless of the position of the lamp in the lamphouse. The entire weight of the lamp and lamphouse is carried on Norma ball bearings so that the movements on the stage can be followed with the utmost ease and without the

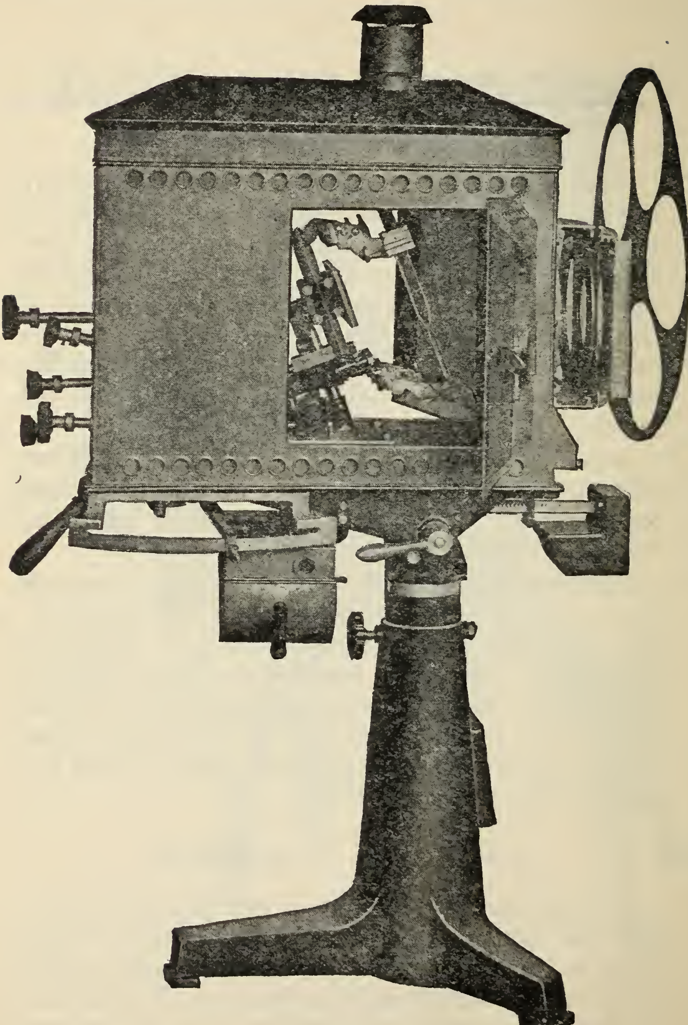


FIG. 269
Power's Spotlight

jerky effects commonly seen with the ordinary spotlight. The control handles at the rear of the lamphouse are fastened to telescoping tubes, thereby eliminating the annoying feature of long rods projecting through the rear of lamphouse when lamp is in extreme rear position.

Power's Type "E" spotlight is equipped with the Power's Type "E" lamp which is fully described in another part of this book. The very great superiority of the Type "E" equipment has been fully demonstrated in connection with Power's projectors and is a strong evidence of the care taken in designing and building Power's Type "E" spotlight.

One Iris dissolver, two lens holders for 6 and 8 inch lenses and a color wheel with 5 inch openings are included as regular equipment for each Type "E" spotlight.

CARRYING CAPACITY OF COPPER WIRE

B. & S. Gauge	Circular Mils	Table A Rubber Insulat. Ampere	Table B Other Insulats. Ampere
18	1,624	3	5
16	2,583	6	8
14	4,107	15	16
12	6,530	17	23
10	10,380	24	32
8	16,510	35	46
6	26,250	50	65
5	33,100	54	77
4	41,740	65	92
3	52,630	76	110
2	66,370	90	131
1	83,690	107	156
0	105,500	127	185
00	133,100	150	200
000	167,800	177	262
0000	211,600	210	312
	200,000	200	300
	300,000	270	400
	400,000	330	500
	500,000	390	590
	600,000	450	680
	700,000	500	760
	800,000	550	840
	900,000	600	920
	1,000,000	650	1,000
	1,100,000	690	1,070
	1,200,000	730	1,150
	1,300,000	770	1,220
	1,400,000	810	1,290
	1,500,000	850	1,360
	1,600,000	890	1,430
	1,700,000	930	1,490
	1,800,000	970	1,550
	1,900,000	1,010	1,610
	2,000,000	1,050	1,670

The lower limit is specified for rubber-covered wires to prevent gradual deterioration of the high insulation by the heat of the wires, but not from fear of igniting the insulation. The question of drop is not taken into consideration in the above tables.

MEASURING WIRE

First scrape off the insulation, then take one strand of wire and insert it in the smallest slot possible on a Brown and Sharp wire gauge. Find out (by using wire table) the number of circular mils contained in the one strand, then multiply the number of circular mils by the number of strands in the wire, then refer to wire table on page 650, and find the nearest corresponding number of circular mils, look opposite to find what size wire you have.

For instance, suppose we are going to measure a length of stranded wire, we first take one strand and measure with B. & S. gauge. Let us take it for granted that it measures No. 14, now find out by using table on page 650 how many circular mils there are in a No. 14 wire—4,107; next count the strands in the wire and say we count 7; then, by multiplying the 4,107 by 7 we will find the circular mils in the whole wire or $4,107 \times 7 = 28,749$ circular mils in the whole wire. Now find the nearest corresponding number to 28,749 in circular mil table and we find it is 26,250, and looking over to the first column we find this to be a No. 6 wire

POINTS TO REMEMBER

To find the positive or negative polarity when connected up, strike the arc and let same burn for a second or two, then throw off the switch and look to see which of the carbons cool off first. Whichever remains red the longest is the positive and this should always be the carbon in the top jaw of lamp.

If you find that the lower carbon remains red longer than the top, then your lamp is burning upside down, or in other words, the positive line is connected to the lower jaw instead of the top. This can be remedied by changing the wires at arc, wall-switch, or table-switch.

Should both carbons remain red the same length of time you have alternating current.

The Department of Water Supply, Gas and Electricity call for the use of link fuses in the operating booth on the machine line. Cartridge fuses are not allowed.

Always see that all electrical connections are tight and that lamphouse, etc., is free from grounds.

Examine the lamp leads every so often. Remember that copper oxidizes when overheated.

See that you have enough carbon in holders to run the reel through.

When buying or fitting condensers and mounts for same, remember to leave room in mounts for the expansion and contraction of condensers. Remember that cold draughts will break your condensers.

The joint resistance of two conductors connected in parallel is equal to the product of the resistances, divided by their sum.

The joint resistance of any number of resistances connected in parallel is the reciprocal of the sum of the reciprocals. (The reciprocal of a number is 1 divided by that number.)

The total resistance of a number of resistances in series is equal to the sum of all of them.

The heating of the rheostat is proportional to the square of the current it carries.

Drop in voltage is proportional to the product of the current and resistance for a direct current circuit, and the product of current and impedance for an alternating current circuit.

To find the size of a picture obtainable under given conditions and lens. Multiply distance from center of lens to screen by one dimension of slide or film and divide by equivalent focal length of lens, taking all measurement in inches.

To find focal length of lens for a given slide or film to produce a given size of picture. Multiply slide or film dimension by length of throw and divide by dimension of picture. All measurements in inches.

To find length of throw needed to obtain a certain size of picture. Multiply required picture dimensions by focal length of lens and divide by slide or film dimension.

One foot of film contains 16 pictures.

One turn of the crank runs off 1 foot of film.

Resistance of any conductor is equal to its length in feet divided by the area in circular mils, multiplied by the resistance per mil foot which is 10.8 ohms.

Resistance of all metals increases with an increase of temperature.

Resistance of insulating material and carbon decreases with an increase of temperature.

To set the flicker shutter, loosen up the set screw so that shutter revolves freely on the shaft, now turn shutter till single set screw is in groove of shaft and then tighten, now loosen the two screws on the collar and open the gate of machine. Turn the balance wheel till you see that the intermittent movement is just about to revolve, then the large blade of shutter should just be coming up to cover lens, and should be so fixed that the blade of shutter is covering the front of lens as long as the intermittent sprocket is in motion.

Another way is to set it as follows: Turn the balance wheel till two teeth of the intermittent sprocket have passed a given point; this represents one-half of a picture or, in other words, that the picture has completed one-half of its movement, now set the large blade of the flicker shutter dead over the front of lens.

Always keep carbon holders clean so that carbons make good contact.

Always have a spare belt (driving and take-up) near at hand.

Keep your fingers off the glass surfaces of lenses.

Oil machine often a little at a time, keep oil off the floor of the booth.

Keep oil off the friction discs.

Never use oil on the arc lamp. Use graphite.

Renew motor brushes, whenever necessary, and keep grease cups filled.

DYNAMOS

A dynamo electric machine is a device for converting mechanical energy into electric energy. The word dynamo is generally understood to mean a machine for converting mechanical energy into electrical energy, and the word motor means a machine for converting electric energy into mechanical energy, the essential parts of a dynamo and motor are the same, namely—the armature and field magnet.

Dynamos are divided into two general classes, according to the character of the current they deliver. A direct current dynamo delivering a current that always flows in one direction, that is, the current never reverses, though it may change in value or pulsate.

Alternating current dynamos or alternators, deliver a current that periodically reverses its direction of flow, the number of reversals per second depending on the number of poles in the dynamo and on the speed of rotation.

A direct current dynamo usually consists of a series of conductors arranged on the surface of a cylindrical iron core or in slots near the surface, the conductors in most cases being parallel with the axis of the core.

The core is mounted on a shaft that is supported on bearings so that the armature can be rotated near the pole faces of a field magnet. This magnet is excited by one or more field coils. Any even number of poles may be used according to the size and type of machine.

The principal parts of a dynamo are: armature core, bands on armature core, commutator, shaft, field coils, pole faces, brushes, rear end bearing, front end bearing, rear end journal, front end journal, terminal block and bedplate.

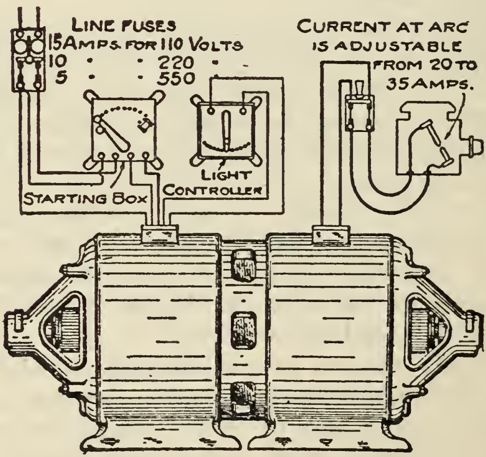


FIG. 270

THE TRANSVERTER

Some little time ago Mr. H. McLellan, technical editor of the "Exhibitors' Trade Review," made a trip to the Hertner Electric Co. plant in Cleveland, Ohio, and while there made a study of the construction, operation and care of the Transverter. The following information on the Transverter was prepared by Mr. McLellan and is a fair sample of the useful technical articles found weekly in the projection pages of the "Exhibitors' Trade Review."

In all motion picture houses it is necessary to use equipment of some kind that will make the electric current supplied by the local power company usable in the projection arc.

If the power supplied is direct current, the equipment may be only a rheostat which will absorb and dissipate in the form of heat all the electric energy taken from the line in excess of that required to maintain the arc. If the supply is alternating current, the equipment may be a rheostat for this same purpose, or a choke coil or transformer for reducing the AC voltage to that used in the AC arc: Or, it may be a mercury arc rectifier or a rotary converter, either of which changes alternating current to a direct current of no more constant voltage than that of the power line; or the equipment may be a motor generator to operate from either AC or DC to secure either direct current of lower constant voltage or direct current at constant amperes, which is still better,

more suitable and economical for use in the projection arc than direct current at constant voltage.

An AC arc is noisy and gives an unsatisfactory quality and quantity of light for projection purposes. For this reason the DC arc is in almost universal use in all modern theatres. Houses that were using alternating current in the arc are discontinuing it and adopting direct current, the former being used only in event of emergency. In fact, many of our most modern theatres will not even tolerate alternating current for emergency purposes, preferring instead to provide

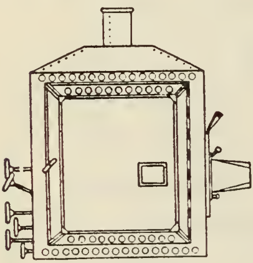


FIG. 271 FIG. 272 FIG. 273 FIG. 274

themselves with duplicate generating equipment.

Being familiar with the fundamental operating characteristics of an electric arc, one can readily understand why direct current at constant amperes is more economical and suitable in every respect for a projection arc than direct current at constant voltage, also it is necessary to use some form of rheostat as a ballast with the latter and not with the former. Let us, therefore, consider the operating characteristics of an electric arc.

Let it be understood that an arc lamp is not an electric arc. The lamp (Fig. 271) is merely the mechanical mechanism for holding and adjusting the carbons to proper position with reference to the lenses, the whole being enclosed in a metal casing. However, with this mechanism and a suitable supply of electricity, we can get an electric arc between the carbons (Fig. 274), and it is the characteristics of this electric arc that we will consider.

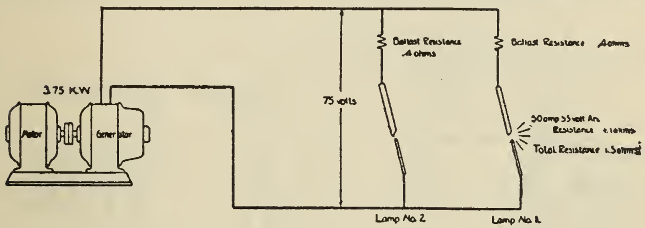


FIG. 275

First, it is well to know that there are three indispensables to the maintaining of an electric arc, namely, amperes, voltage and resistance.

The number of amperes used in the arc determines to a large extent the amount of light we will get from it.

The voltage is the electric pressure required to force the amperes across the space or gap (Fig. 272) between the carbons of the lamp. This same gap, with its electric arc gases, is the resistance (see Fig. 274.)

Having our lamp mechanism and a supply of electric current, we must first bring the carbons

into contact with each other (Fig. 273) in order to complete the electric circuit and start current flowing. Then when we separate the carbons we will get between them an electric arc which consists of highly heated particles of carbon and incandescent gases between the ends of the carbon. The greater the distance of separation between the carbons the greater will be the ohmic resistance of this gap to the flow of amperes; therefore, more and more voltage is required to overcome this resistance and maintain the flow of amperes across this gap. Now, with carbons in

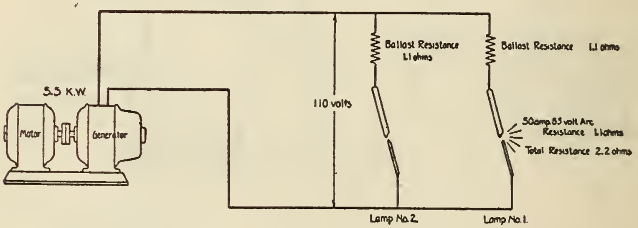


FIG. 276

contact (Fig. 273) as we have them when first making the circuit, we have what is termed a short circuit, i. e., a circuit of practically no resistance, requiring only a very low voltage, but as we separate the carbons, more and more volts are required for maintaining the flow of current. And finally, with lamp carbons separated to what is termed a normal arc length, we find approximately 55 volts being used in a 50 ampere arc. This 55 volts times the 50 amperes equals 2750 watts, which is the amount of electric energy used in such an arc.

THE ELECTRIC CURRENT SUPPLY

However, in using direct current at any constant voltage, the voltage must be somewhat higher than the 55 volts required in the arc. This, in order that some form of rheostat may be used as a ballast to stabilize the arc, at least to the extent of preventing an excessive flow of amperes when the arc length is decreased or short circuited. In fact, without a ballast, a constant voltage source of current would very promptly blow a fuse. A slight increase in the arc length above

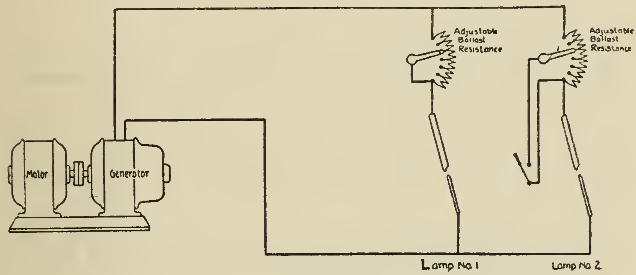


FIG. 277

normal will cause a gradual decrease in the amperes before the arc breaks entirely. The higher such constant voltage above the 55 volts required in the arc, the greater will be the power bill, until at 110 volts we must pay for twice as much energy as we are getting the benefit of in the form of light from the arc. The higher this voltage, however, the more stable the operation of the arc and the easier it will be to get two arcs simultaneously for dissolving the pictures, if the current is taken from equipment limited in capacity near to our needs. This, because the two arcs would neces-

sarily be connected in parallel, and when we have parallel paths for current the lowest resistance path takes most or all of the current, depending on the relationship of the resistance of one arc circuit to that of the other and on the ability of

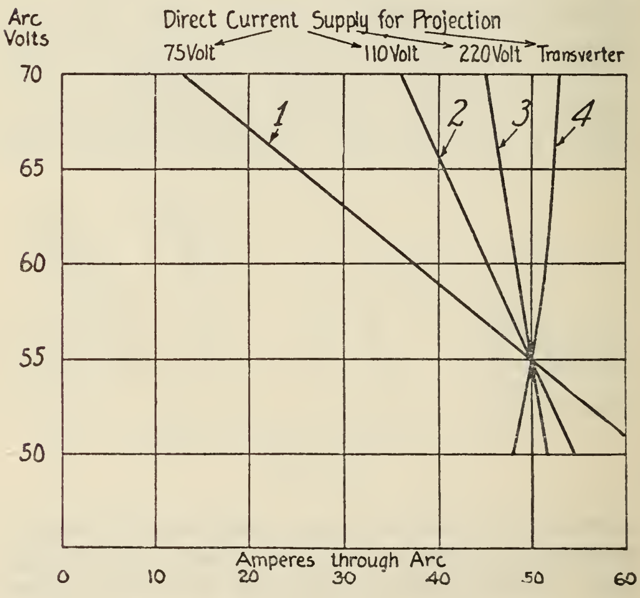


FIG. 278

the equipment used to maintain its voltage constant.

As an example, suppose we must use a 50 ampere arc for our projection requirements and compare results to be obtained from both a 55 ampere 75 volt outfit and from a 55 ampere 110 volt outfit.

Fig. 275 shows the 50 ampere 75 volt capacity outfit connected to a paralleled two-lamp circuit. Assuming we have lamp No. 1 in use with 50 amperes and a normal 55 volt arc length, the total resistance of this circuit is 75/50, which equals 1.5 ohms. The voltage of the arc is 55,

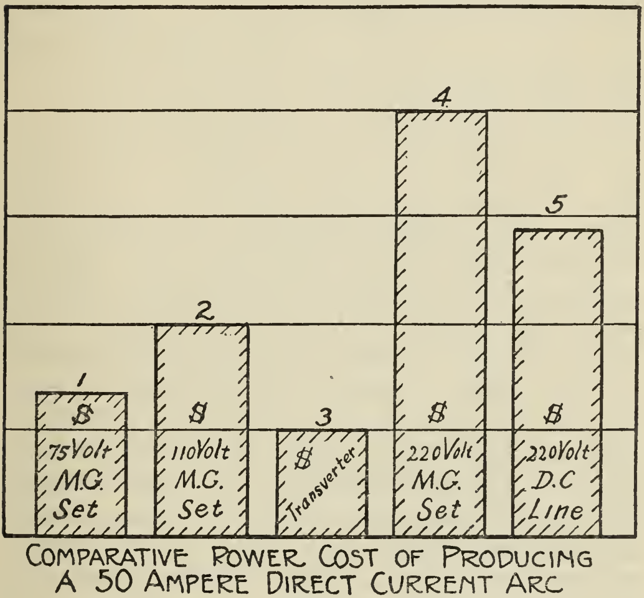


FIG. 279

leaving 75 less 55, or 20 volts to be lost in the ballast, and with 50 amperes a ballast resistance of 20/50 or 0.4 ohms is required. Now, if we bring the carbons of lamp No. 2 together, as we must to start the second arc, we will be placing the 0.4 ohm resistance of its ballast in parallel

with the 1.5 ohms resistance of lamp No. 1, with the result that with a 75 volt line the 0.4 ohm circuit attempts to take 187.5 amperes which, added to the 50 in lamp No. 1, makes 237.5 amperes, which at 75 volts is a 17.8 K.W. load, which is a 350 per cent overload on the 3.75 K.W. machine. At such an overload, this equipment cannot maintain its voltage constant, i. e., the voltage will decrease, with the result that the amperes and the light from lamp No. 1 will decrease to such an extent that it may go out entirely.

Fig. 276 again shows a paralleled two lamp circuit, and while the current supplied in this is also from a 50 ampere capacity generator, it is at 110 volts. The machine's capacity is 5.5 K.W., and assuming again we are using lamp No. 1 with 50 amperes and carrying the normal 55 volts arc length, the voltage to be lost in the ballast is 110 less 55, or 55, and with 50 amperes flowing, the required ballast resistance is 55/50 or 1.1 ohm, but the total resistance is 110/50 or 2.2 ohms. Now, when we bring together the carbons of lamp No. 2 we will have paralleled a 1.1 ohm of ballast with the 2.2 ohms resistance of No. 1 lamp circuit, with the result that we get 110/1.1 or 100 amperes in lamp No. 2 circuit. This, with the 50 amperes used in the other lamp, makes a total of 150 at 110 volts or 16.5 K.W., which on the 5.5 K.W. machine is only a 200 per cent overload. As this overload is much smaller than before, this machine will not only come nearer to maintaining its voltage constant, but there is less necessity for its doing so, because the 1.1 ohms of ballast used in this case has a much greater stabilizing effect

than the 0.4 ohms ballast used with the low voltage machine.

Carrying the illustration one point further. Suppose the voltage of the generators were 220, calculating in the same manner with a 50 ampere arc the capacity of the machine will be 11 K.W., the rheostat required would have a voltage drop of 220 less 55 or 165 and a consequent resistance of 165/50 or 3.3 ohms.

On starting the second arc it would take 220/3.3 or 67 amperes, a total for the two arcs of 67 plus 50 or 117 amperes and an overload of 134 per cent.

However, when the parallel system of arc operation is used, the usual practice is to have generator voltage about 80 to 85 volts. Then in order to minimize the overload and its disturbing effect when striking an arc, an adjustable high resistance ballast is provided for each lamp circuit, as shown in Fig. 277.

The entire resistance of the rheostat to be in the circuit when striking an arc, after which the operator must either make adjustment of the resistance or with a switch connected as shown on lamp No. 2, Fig. 277, short-circuit the greater portion of it, in order to get the amperes required for projection. This is not a convenient, but with many MG sets of that type is a necessary, arrangement where such low voltage supply is used with parallel arcs.

The figures given above with reference to constant voltage generators supplying current to motion picture arcs, will apply to any constant voltage source of direct current whether that

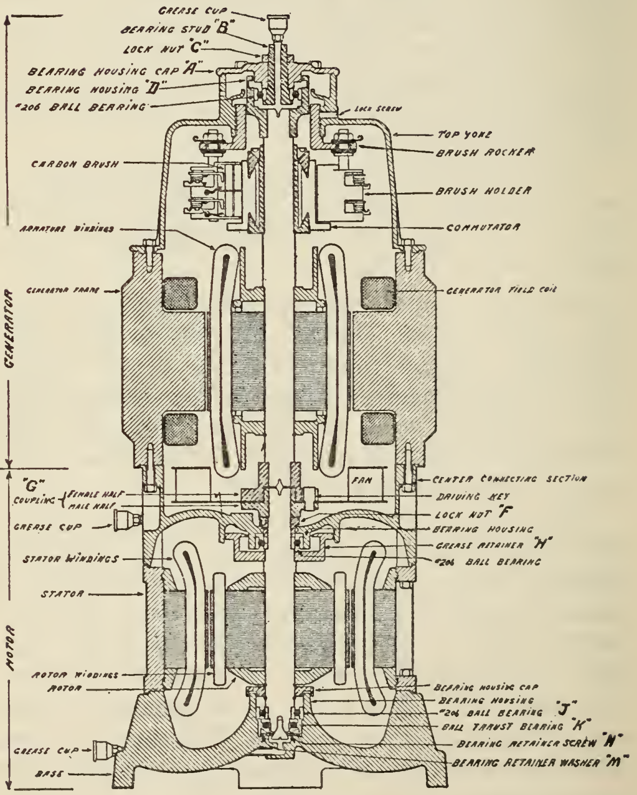

GREASE CUP
BEARING STUD "B"
LOCK NUT "C"
BEARING HOUSING CAP "A"
BEARING HOUSING "D"
#206 BALL BEARING
LOCK SCREW
TOP YOKE
BRUSH ROCKER
CARBON BRUSH
BRUSH HOLDER
ARMATURE WINDINGS
COMMUTATOR
GENERATOR FRAME
GENERATOR FIELD COIL
GENERATOR
CENTER CONNECTING SECTION
"G"
COUPLING
FEMALE HALF
MALE HALF
FAN
DRIVING KEY
LOCK NUT "F"
GREASE CUP
BEARING HOUSING
GREASE RETAINER "H"
STATOR WINDINGS
#206 BALL BEARING
STATOR
MOTOR
ROTOR WINDINGS
ROTOR
BEARING HOUSING CAP
BEARING HOUSING
#206 BALL BEARING "J"
BALL THRUST BEARING "K"
GREASE CUP
BEARING RETAINER SCREW "N"
BASE
BEARING RETAINER WASHER "M"

FIG. 280

source be a mercury arc rectifier or a rotary converter.

The cut, Fig. 278, shows how the current varies with arc length on the various types of equipment. The voltage of the arc is shown in the vertical column of figures on the left marked "volts," the arc current is donated above, marked "amperes." It will be noted that the lines all cross at the point 55 volts and 50 amperes. Above this, i. e., at higher volts or greater arc length, curve No. 1 leads rapidly to the left, indicating

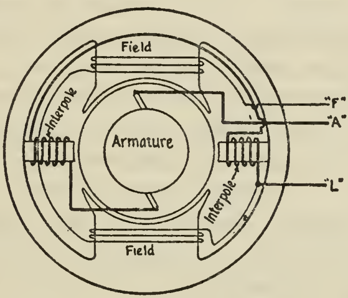


Fig. 281

fast decreasing current. This corresponds to the performance of the 75 volt machine. Curve No. 2 is more nearly vertical and shows that on the 110 volt machine the regulation is much better, while curve No. 3 approaches closely the vertical line which represents constant current. Curve No. 4, that of the Transverter, shows a slight current climb with increasing voltage, less, however, than the drop when using the 220 constant voltage generator.

Comparative power costs under the conditions shown are illustrated by the relative heights of the blocks, Fig. 279.

No. 1 is that corresponding to the 75 volt machine, No. 2 the 110 volt machine, No. 3 the Transverter, No. 4 the 220 volt machine if a motor generator and No. 5 the 220 volts if taken directly from a 220 volt D.C. supply line.

While we see that increasing the voltage of such constant voltage machines tends to improve the stability of the arcs, it results in increased cost for power with no possibility of getting ideal results at the arcs. To overcome these difficulties and at the same time be able to get from one machine simultaneously two such arcs of equal amperes and light value, the arcs must be connected in series and we must use a constant current machine. With this equipment only the desired results can be accomplished. There is no power waste in ballast—power bills are therefore reduced to a minimum. Being in series, the amperes in both arcs are identical and in dissolving there is no change in light intensity. The source, being a constant current machine, the amperes and light do not decrease if the arc length increases from 55 to 60 or even 70 volts, so that the arc is not lost or even noticeably changed. The Transverter, a description of which follows, is such a machine. In fact, it is the pioneer in this class of equipment. The first units were sold and installed in theatres in 1915, and from all reports these early machines as well as the later ones are giving their users entire satisfaction. Therefore, a detailed description of the Transverter, with the

latest improvement made in it, should prove of interest.

THE TRANSVERTER

The AC to DC Transverter is a vertical ball bearing motor generator consisting of an interpole direct current generator above and directly connected to a squirrel cage induction motor below. The vertical design lends itself well to the usually narrow confines of the average projection room, where most of these machines are installed. This because the floor space required comprises a circle only of about 19 in. to 21 in. in diameter, depending on the capacity of the machine. Such construction involves no change or adaptation of design, as the machine is built and intended for this purpose alone and is not in any respect a modification of power apparatus.

The height and weight of the Transverter also varies with its capacity, the limits being from 33 in. to 45 in. and in weight 500 to 1500 lbs.

ITS BEARINGS

Ball bearings are used throughout and, as claimed by the manufacturers, there is no question but that when properly mounted they are highly efficient and durable, requiring only a minimum of care. Automobile engineering practice, where ball bearings have had some twenty years of successful application, can be credited for showing how to properly mount and care for such bearings.

We find in the mounting of ball bearings it is universal practice to tightly hold the inner race of the bearing on its seat on the shaft and permit the outer race to have a free fit in its housing, yet without lateral shake, so that this outer race has enough freedom to adjust itself lengthwise of the shaft in order to avoid any binding action or end thrust between itself and the inner race.

To accomplish this, each of the annular ball bearings used in Transverter is mounted so that the inner race is firmly bound to the shaft. It is pointed out, however, that as five or six ten-thousandths of an inch variation in bore is the commercial standard limit of accuracy set by the engineering societies and manufacturers of such bearings, and since the fit on the shaft must necessarily be tight, but not too tight, the limits of five to six ten-thousandths precludes the possibility of making a fit in this manner interchangeable, the best practice, therefore, is to clamp the inner race between a shoulder on the shaft on one side and a lock nut on the other. This construction has been adopted throughout in the Transverter.

The cut, Fig. 280, shows the machine in cross section. The lower part is an induction motor of the required frequency phase and voltage, the rotor of which is supported on both ends of its shaft by annular ball bearings. The lower bearings are located in the housing of the base of the machine, the annular bearing taking side load, while all of the weight of the rotating elements is supported by the thrust bearing *K*.

It will be noted that the bearing *J* rests against a shoulder of the shaft above and against a thrust

bearing *K* below, thus the weight of the rotor and armature takes the place of a nut in binding the inner race of *J* to the shaft.

The thrust bearing *K* rests on a spherical seat which renders it self-aligning. A screw set into the bottom of the shaft holds all the members of the thrust bearing loosely in place, which is an aid in assembling. When the rotor shaft is put into its proper position the thrust *K* will rest on the washer *M*, relieving screw *N* of any connection with the bearing or any of its parts. Both of these bearings are enclosed and guarded against dirt, grit and moisture by the bearing housing cap on the motor shaft. A grease cup shown on the side of the machine supplies the lubrication for both bearings.

The center bearing is seated on the upper part of the rotor shaft, as already stated. It is held thereon by a lock nut *F* pressing it against the opposing shaft shoulder. The grease retainer *H*, mounted on the shaft and revolving with it, completes the enclosure. A second grease cup shown on the side carries lubrication to a tube entering above the bearing.

The upper bearing of the generator is in the housing *D*, being a free fit therein. Its race is held on the cap *A* by the stud *B*, secured by the lock nut *C*. This stud is hollow and takes a grease cup above, leading the grease into the housing *D* immediately below the bearing. A glance will show that there is a triple barrier against the entrance of dirt or moisture, one where the cap *A* sets into the housing *D*, a second one where the extension of the top yoke fits around *D*, and a

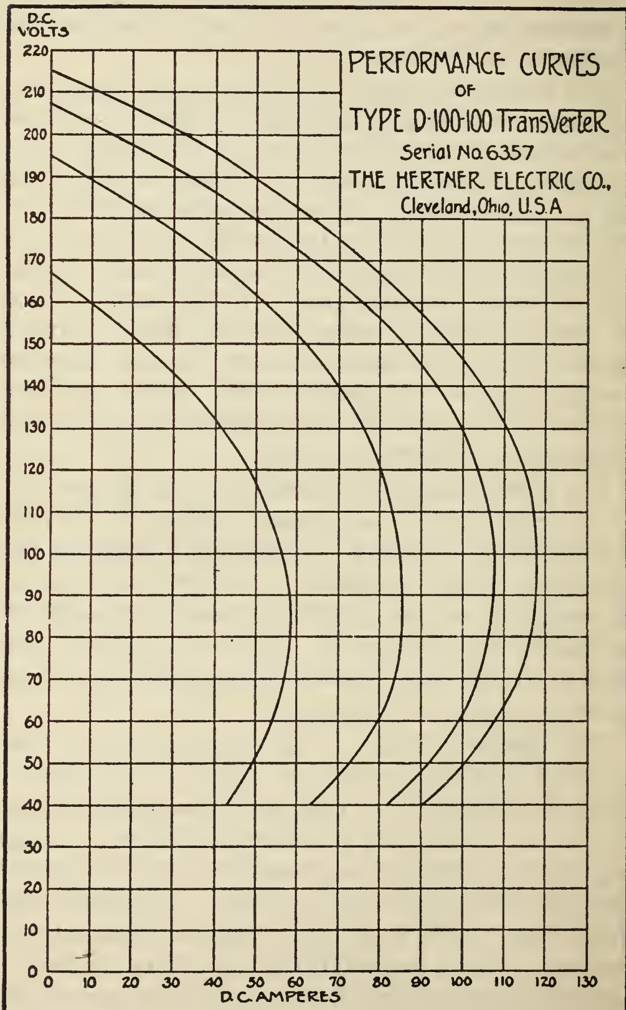

D.C. VOLTS
PERFORMANCE CURVES
OF
TYPE D-100-100 TransVerteR
Serial No. 6357
THE HERTNER ELECTRIC CO.,
Cleveland, Ohio, U.S.A
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130
D.C. AMPERES

FIG. 282

third where D is surrounded by the cylindrical extension of the brush rocker casting.

Mounted in this manner, the bearings demand practically no attention, an occasional half turn, say once each thirty days, of each grease cup being sufficient.

VENTILATION

At the extreme top of the rotor shaft is located the male half of the coupling, the female half being on the generator shaft. It has a possibility of a small amount of self alignment. Between the two halves of this coupling is located a centrifugal fan which ventilates both motor and generator, drawing in air from above and below and exhausting it at the sides of the machine. It is claimed by the manufacturers that the power required to turn this fan is much more than offset by the increased efficiency of the unit working at the lower temperature due to the excellent ventilation.

LUBRICATION

It will be noted also that grease (not oil) is used in these bearings. Ample provision is made for any oversupply of grease in the upper bearing to be thrown out of the bearing housing into a compartment in the top yoke, from which it will drain to the outside of the machine. There is, therefore, no possibility of grease from the bearing getting into brush-holder or commutator, where it could cause serious trouble.

THE MOTOR

In most respects the AC motor is of conventional design. Its stator, however, with its winding, is removable and interchangeable with others for different voltage, and to a limited extent, for different phases. This makes such an alteration of the machine a simple matter and a great convenience both in original assembly at the factory and for a customer or dealer.

The rotor of the motor is also of special interest. It is wound with copper consisting of flat strips forced into a very large number of diagonal slots in the surface of its laminated core. The ends of these strips are shaped to overlap each other and then acetylene welded into a solid copper ring, entirely eliminating any possibility of trouble from open or partly open circuits of the rotor.

THE GENERATOR

The generator has on its main poles shunt fields made up of enameled wire and thoroughly well insulated otherwise. Two interpoles take care of commutation, the series winding on these being made up of asbestos cotton covered wire which also is thoroughly insulated from the pole cores.

The armature is made up of a well laminated core in the slots of which are imbedded insulated form wound coils, the ends of which, by an improved process, are securely soldered into the bars of the commutator.

THE COMMUTATOR

The commutator, brush rigging and brushes are, in a sense, the heart of any generator, as it is

there that trouble will first develop if there is anything lacking in either its design or the quality of the material used. In the Transverter commutator cold drawn copper bars are used, which insure absolute uniformity of density and temper of metal throughout, and these bars, as well as the mica segments, are punched to exact uniformity of size, and all are assembled between mica end rings into a steel core under many tons of hydraulic pressure, thus eliminating any possibility of warpage or loosening of bars in service.

BRUSHES AND HOLDERS

The brush-holders are of brass and of the most modern type, having adjustable tension fingers that hold in contact with the commutator surface the carbon brushes, which are electrically connected to the brush-holder castings with flexible pigtails, thus minimizing losses and eliminating any possibility of the joints or tension springs being injured by such currents.

INTERCHANGEABILITY

The various parts of Transverters of any given size are interchangeable, and while it is seldom that anything more than a set of brushes is required by a user, the interchangeability of the parts is of advantage to the manufacturer in assembly of the machines, and insures that in event that a user should have need for any part, it may be obtained almost immediately from the nearest Transverter dealer.

The cut, Fig. 286, shows in the center a Transverter without panel, and around it the several unit parts comprising it as they would appear if the machine were disassembled.

ELECTRICAL DESIGNS

Electrically the generator design is rather unique, being intended to deliver current automatically no matter what the arc conditions

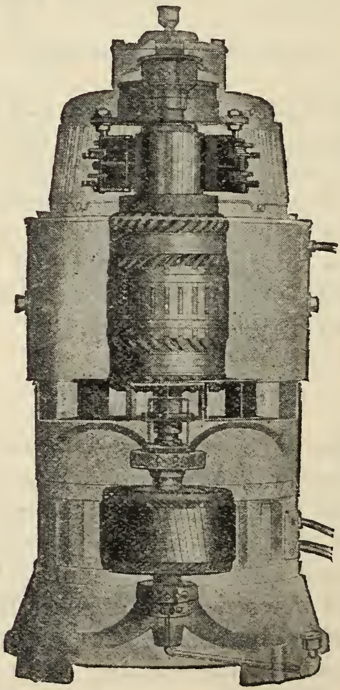


FIG. 283

might be, the plan worked out has resulted in a very reliable and simple construction.

Fig. 281 illustrates the electrical connections of this generator.

The action of an electric generator is that the armature is revolved in the field of a magnet. As a result, current can be drawn off the armature. The amount of current is determined largely by the resistance opposing its flow. Incidentally this current flowing in the windings of the armature makes a magnet of it, and in the Transverter advantage is taken in this fact to so direct this magnetism as to oppose the strength of the fields.

As the current flow increases the armature more strongly opposes the field, with the result that over a wide range of increasing voltage the resulting current is constant.

A second pair of field coils is added and placed on a pair of auxiliary poles called interpoles, which act on those parts of the armature winding under the brushes. Their action is such as to produce sparkless commutation.

The results obtained from the Transverter are not, of course, due only to the combination of the materials and parts as outlined above but due largely to a careful proportioning of them as well as the proper selection of material. Finally, the correct performance of the machine is due to the proper positioning of the brushes on the commutator and the correspondingly correct location of the interpoles which, contrary to usual practice, are made adjustable.

The location of the brushes and the interpoles is a factory adjustment and should never be

changed thereafter. A change in the location of both or either would seriously interfere with the proper current delivery and commutation of the machine. There is no excuse for altering this adjustment.

PERFORMANCE

On making a test of a double hundred machine it was found that, on starting, the voltage immediately went to about 220 and just as quickly dropped back to 150. This is accomplished by the use of a relay in the panel which inserts resistance into the field as soon as the voltage builds up to the high value. Two things are claimed for this device—protection to the field from abnormally high current and heat, and a saving in power consumption, because of full strength field applied to generators running open circuit. The loss in the shunt field and also the iron losses of the machine would be abnormally high.

With the voltage back at 150 and one of the lamps shorted by its switch, the other arc was started in the usual way. It was found to burn about 100 amperes and at about 60 volts on normal length. The switch across the second arc was then opened, the carbons began to glow, and, when drawn apart, produced a second arc. Both arcs were now burning at about 104 amperes at a total of about 120 volts for the two. On short circuiting the first arc the voltmeter again returned to the neighborhood of 60, while the amperes remained at 100. Allowing this arc to burn without adjustment, watching the voltmeter and ammeter, the current, which was 100 at 60, went to 105 at 70, and 108 at 80, and 109 at 90. Fol-

lowing the curve below mentioned it would have been found to begin to decrease slightly below this value had the test been carried up to and beyond 100 volts. Such an extremely long arc has no value in practice, but it illustrates the remarkable constancy of the electric current.

The curves shown in Fig. 282 illustrate this point very clearly. Volts are shown vertically and amperes horizontally. The four curves are for four different rheostat settings corresponding to 50, 80, 100 and 110 amperes on the arc.

Let us see how the test and the resulting curves will help to answer questions such as the following:

1. When both arcs are open and the machine running and showing 150 volts, why does not the fuse blow upon dead short circuit?

2. Why does not the current diminish when burning one arc if that arc is allowed to burn up to a 70 or 75 volt length?

3. What happens to the current in the arc upon starting the second arc?

4. What happens to the current in either arc upon shorting the other?

1. What happens when running on open circuit at 150 volts, or what would happen were the relay cut out so as to give the full 220 volts is simply this: Immediately upon short circuit the current generated will set up an action which demagnetizes the fields, thus producing less and less voltage, following down the curve till it practically hits the bottom horizontal line, which shows that the voltage on the line is zero and the amperes 90.

When the shorting of the generator is accomplished by closing the switches across the arcs, the current will momentarily increase somewhat above that indicated by the curve, but at no time is the load sufficient to cause the blowing of a fuse. The machine will run indefinitely with switches closed on the short circuiting position, with less load on the A.C. line than if run on open circuit.

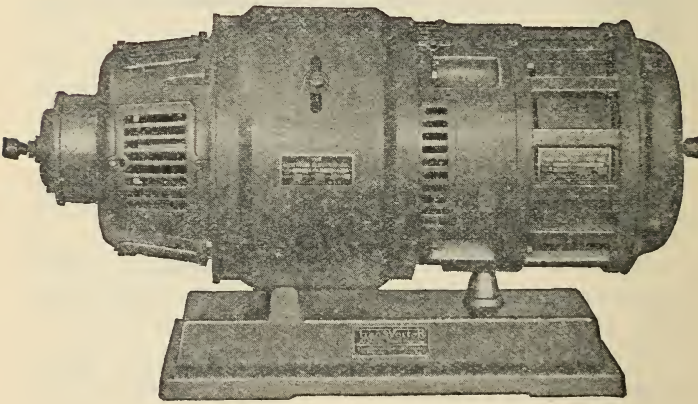


Fig. 284

2. Upon opening the arc gradually from its normal length to upward of 70 volts, the current increases slightly. This can readily be traced on the curve, the current being the same at 60 and at 120 volts and slightly greater at points between, so that could a single arc be drawn out to 120 volts the current would gradually rise to 109 amperes at 90, then again decrease to normal at 120 volts.

3. The third question is answered by the second, because on starting the second arc the current is practically unaffected as the voltage rises rapidly to about double its former value.

4. When either arc is shorted the current value follows the curve as the voltage decreases and again assumes the value corresponding to 55 or 60 volts. In fact, it will soon be found, when handling the machine, that the current can never depart except momentarily from the curve assigned to it for any given voltage.

EFFICIENCY

The overall efficiency from line to lamps varies from 65 per cent to 75 per cent, depending on the size and the number of arcs burning.

HIGH INTENSITY ARC

It will be of interest to those who are contemplating the use of high intensity arc to know that the constant current generator is well fitted to operate this lamp; in fact, constant current is much better adapted to the needs of the high intensity arc than constant voltage, because if on account of uneven carbon consumption or for any reason the arc length should vary, the change in voltage would quickly accelerate or retard the driving motor of the arc so as to compensate; whereas, if the motor were operated across the line or even across the arc on a constant low voltage source, its speed, and consequently its arc

regulation, would be but slightly affected by any variation in arc action.

STARTERS

With all single phase Transverters a special starter is furnished and included in the price of the equipment. This because a unique starting device is employed. In its operation alternating current is led into one of the brush-holders of the generator, out of a special third brush and thence through the stator. The generator acts as a repulsion motor getting the unit up to speed. As the machine nears its running speed, the motor takes hold and the current falls off from the starting to the idling value. The starting switch is then thrown into the running position and the generator is ready for service.

Two and three phase Transverters are furnished either with or without motor starter. The small sizes do not require them and on larger sizes, on account of starting conditions always being without load and the machine being ball bearing, the majority of the power companies waive their rules and permit installation without starter, and those that do insist on them prefer to specify the type of starter to use.

PANELS

A complete Transverter equipment consists of the motor generator and a control panel. Two styles of panel are offered. The style in most general use, panel "A," is a substantial steel cabinet 12x14x6, having mounted inside of it the relay, and generator field regulator, on the outside

the operating handle of the field regulator and both voltmeter and ammeter. The field regulator has capacity to adjust the current from more than the rated output to about one-half. Panel "B," in addition to this, has two single pole quick brake short-circuiting switches mounted in the lower part of the cabinet, the operating handles extending through the cover. These panels and the vertical Transverter are shown in Figures 283 and 285.

TRANSVERTER SIZES AND TYPES

In order to satisfy those who are unfamiliar with the vertical type machines or are prejudiced in favor of the horizontal type, the Hertner Elec-

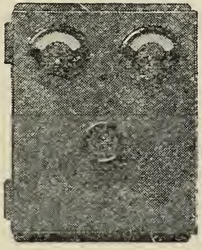


FIG. 285

tric Co. are now offering a complete line of horizontal Transverters, one of them being shown, Fig. 284. These horizontal Transverters are electrically identical with the vertical in design and performance.

Double arc Transverters are offered for any commercial size, frequency and voltage in sizes for from 35 to 125 ampere arcs.

The Transverter is a vertical machine, self-contained and occupies a floor space of less than two feet square. The panel carrying the switches and meters can be located at any point convenient to the operator, while the machine is best placed near a wall anywhere on a floor not subject to vibration, and in a location which is not damp and which affords ready inspection.

A pair of steel lugs will be found on the sides of the generator frame. After the machine is taken out of the crate, it can be very conveniently handled by these lugs, should it be necessary to lift it any distance to its permanent location. When located, it should be placed upon the four pieces of cork composition which are sent with the machine, and which serve to minimize vibration and at the same time insulate the frame from ground. It is not necessary to bolt it down.

Installation Instructions

Wiring—Make connections from the A. C. line service to the starting switch and from the starting switch to motor terminals, 1, 2 and 3; then close the switch and make sure that the armature rotates in the direction indicated by the arrow on the top bearing housing. If the armature rotates in the wrong direction, it must be reversed by interchanging any two of the A. C. motor terminals.

Caution—Do not change connections inside of Transverter unit to correct direction of rotation or polarity. The machines are all checked up complete with their equipment when tested. The motor must be connected to proper side of the

line and connections to panels must be made correctly to bring polarity of the instruments and lamp carbons correct.

Fuses—Fuse the A. C. motor side of these machines only. The D. C. Generator circuit does not require fuses or switches other than shown on the wiring print. The A. C. fuses at the A. C. motor starting switch must be of large enough capacity to carry the maximum load of the machine.

Wiring to Lamps—Use wire of sufficient size to carry rated current of Transverter to connect from L and A on the Transverter to panelboard and lamps. No. 14 or No. 12 size wire may also be used to connect F on Transverter to the F on the Field Regulator in panel board.

The Transverter is a motor generator with the motor below and the generator above, the two being built into one unit.

The shaft of the generator is supported at its upper end in a radical ball bearing, its lower end taking half of a coupling, the other half of which is located at the top of the motor shaft. The shaft of the motor is supported by two radical ball bearings, top and bottom, and a ball thrust, which takes the combined weight of both rotor and armature.

The coupling is so constructed as to carry a centrifugal fan which provides ventilation from above and below, discharging the air out of openings in the side of the unit.

Grease cups are provided for each of the bearings, the latter being enclosed in dust-proof housings.

The driving unit is a simple, two or three phase induction motor of ample capacity, running very close to constant speed regardless of load.

The generator is of the constant current type. The design is bipolar, which lends itself most readily to constant current characteristics as shown in the curve.

The field winding is shunt with interpole windings for commutation. The brushes and interpoles are so positioned relative to the main poles as to get a practically constant current over a wide range of voltage, which, in the double arc machine, reaches from 50 to approximately 115 volts. The position of the brushes on the commutator should never be shifted by rocking them, as this will change the entire characterization of the machine. If any sparking develops, it is due rather to imperfect brush contact than brush position.

Operating Instuctions

Have lamp carbons separated and lamp switches open.

Close motor starting switch.

Close that switch which controls lamp that you do not wish to use.

Permit the generator voltage to build up before attempting to strike the arc, then strike the carbons together quickly and lightly, separating them immediately to about 1-16 of an inch, gradually increasing the separation as the carbons heat up until a proper length of arc is reached. (Note: 55 volts will then show on the Voltmeter,

provided proper size carbons are used and they are set at correct angle.)

Adjust for amperes desired by means of the Field Regulator in panel. (Note: The Regu-

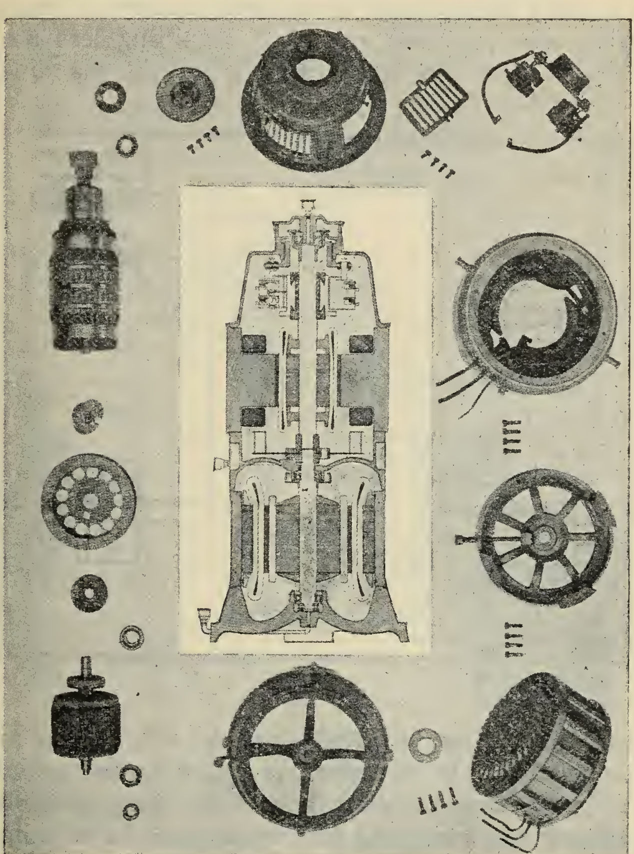


FIG. 286
Parts Making Up the Transverter

lator provides means of obtaining more amperage from the Transverter than its rated capacity. This greater amperage should not be used continuously. It is intended only in order to provide for very dense films or colored pictures. Regulator also provides means of obtaining less amperage than the rated capacity of the machine,

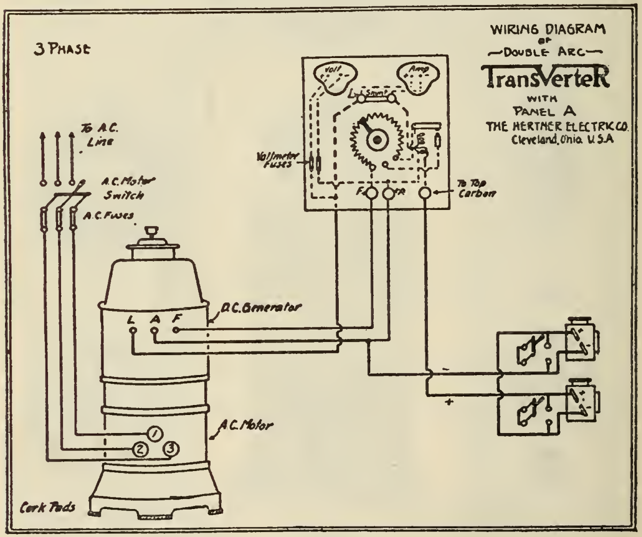


FIG. 287

thus providing for films that do not require so much light. If the operator will take advantage of the provisions that have been made for obtaining the high and low amperage, he will improve the projection and at the same time effect a considerable saving in the projection light bills.)

For Obtaining Two Arcs Simultaneously.—Assuming that one arc is already in operation:

Adjust that arc to about a 55 volt length;

Bring the carbons of the second arc lamp together and while in that position open the switch

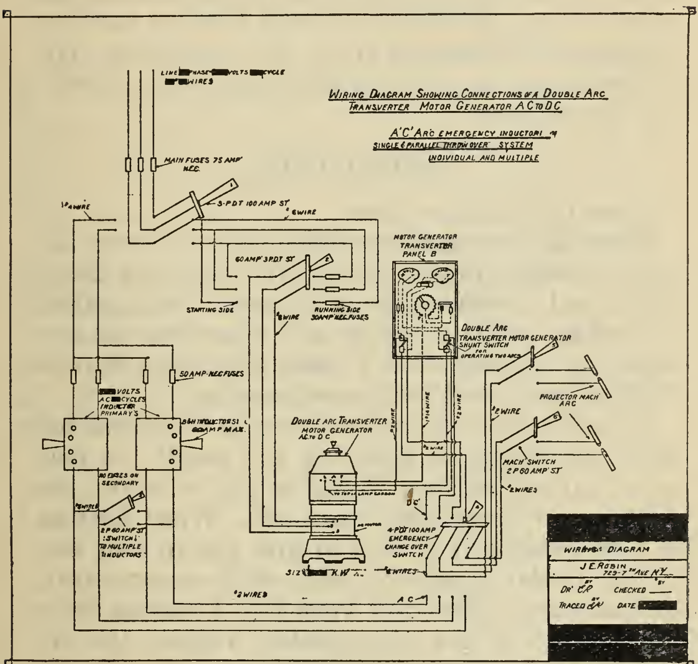


FIG. 288

controlling that lamp, then slowly separate the carbons to about 1-16 of an inch, gradually increasing the separation as the carbons heat up until this second lamp also has a 55 volt arc length. (Note: The Voltmeter on the panel board

will then be indicating combined voltage of the two arcs.)

To discontinue the use of either arc, merely close switch controlling that lamp.

Note: If operator will follow the above instructions carefully, he can heat up the carbons in the second lamp or burn in a new trim of carbons without disturbing the arc of the other lamp. The two arcs can be used simultaneously for dissolving the pictures.

General Care

Keep the machine clean.

Keep the commutator clean (but do not use sand or emery paper on it). If it becomes dirty, hold a pad of coarse canvas or cheese cloth against its surface while running, and when free of dirt wipe the surface with a clean cloth pad that is slightly moistened with pure vaseline.

Do not permit the carbon brushes to become too short, as disastrous sparking will result. A new set of carbon brushes should be put in before the old ones are completely worn out. When putting in new brushes it is well to first put in two, one in each holder at opposite ends of the commutator, then as soon as they are worn into a perfect fit to the surface of the commutator, replace the remaining old brushes with new ones.

The machine has ball bearings and they require a very small amount of lubrication.

The three grease cups on the machine should each be given one turn twice each week. If this is done these grease cups will require refilling once each thirty to forty days.

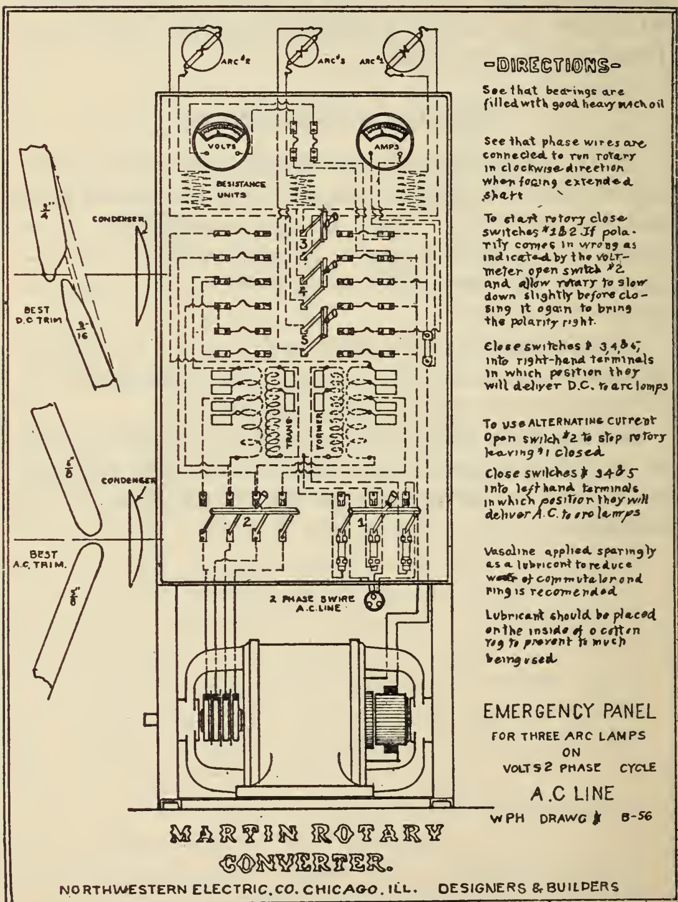
Note: Refill the grease cups with Transverter grease only, as other kinds of grease will be likely to injure the highly polished steel balls and surfaces of the bearings.

Troubles and Remedies

If the brushes are not replaced as explained above, the commutator may become blackened and require attention either by the application of a stone, or, in severe cases, it may require the removal of the armature so as to turn the commutator in a lathe.

Should the bearings become dry or an improper lubricant be used, it may cause the destruction of a bearing and require its replacement.

In case it is necessary to have any repair parts or supplies, order these direct from the factory, giving the serial number on the name plate of the machine.



ARC #2
ARC #3
ARC #1
VOLTS
AMPS
RESISTANCE UNITS
CONDENSER
BEST D.C TRIM
BEST A.C. TRIM.
CONDENSER
TRANS
FORMER
2 PHASE 3 WIRE A.C. LINE
-DIRECTIONS-
See that bearings are filled with good heavy mach oil
See that phase wires are connected to run rotary in clockwise direction when facing extended shaft
To start rotory close switches #1&2 If polarity comes in wrong as indicated by the voltmeter open switch #2 and allow rotary to slow down slightly before closing it again to bring the polarity right.
Close switches # 3,4&5, into right-hand terminals in which position they will deliver D.C. to arc lamps
To use ALTERNATING current Open switch #2 to stop rotory leaving #1 closed.
Close switches # 34&5 into left hand terminals in which position they will deliver A.C. to arc lamps
Vasaline applied sparingly as a lubricant to reduce wear of commutator and ring is recomended
Lubricant should be placed on the inside of a cotton rag to prevent to much being used
EMERGENCY PANEL
FOR THREE ARC LAMPS
ON
VOLTS 2 PHASE CYCLE
A.C LINE
WPH DRAWG # B-56
MARTIN ROTARY CONVERTER.
NORTHWESTERN ELECTRIC.CO. CHICAGO. ILL. DESIGNERS & BUILDERS

FIG. 289

FORT WAYNE A. C. TO D. C. COMPENSARCS

The A. C. to the D. C. Compensarcs is what is commonly known as a motor generator set, that is, two machines, a generator and a motor coupled together and mounted on a common base.

The sets are shipped completely assembled and require only proper installation, filling of the bearings with oil and proper connections to the supply and lamp circuits before putting into service. It should be understood that these compensarcs are special machines for use only on picture projection arcs and cannot be used for ordinary constant voltage purposes.

The complete equipment consists of the A. C. to D. C. compensarc proper, two short-circuiting switches, one for each picture machine, and the panel on which is mounted the instrument and field control rheostat. All single-phase outfits are equipped with proper starter; for the larger multiphase outfits a starting compensator is furnished.

The A. C. to D. C. Compensarc should be installed in a clean, dry, well ventilated location, and, if possible, near to the lamps which it is to operate. Oftentimes a small room adjoining the projection room is provided for the Compensarc; but in some cases where such arrangements cannot be made the machine is installed in the basement of the theatre. Inaccessible locations should be avoided, as such locations will result in the

machines being neglected, allowed to become dirty and perhaps damaged.

It is not necessary to provide foundations for these compensarcs, but the floor on which they are placed should be firm and free from vibration.

A. C. TO D. C. COMPENSARCS

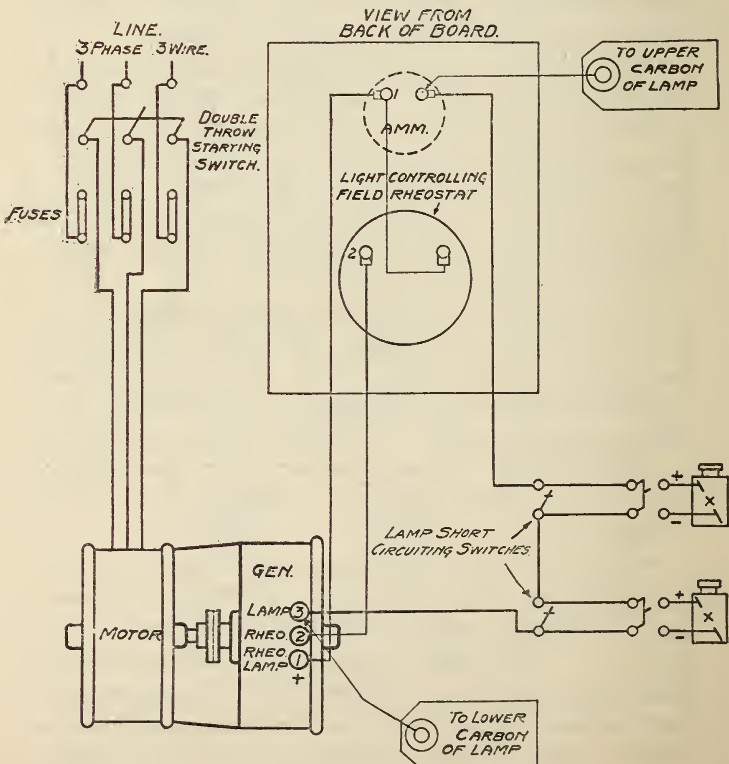


FIG. 290

Connection Diagram for 35-Ampere Lamp Outfit

The machines are clamped to a pair of wooden skids, which form a foundation for the boxing. The machine should if possible be left attached to these skids until it has been conveyed to the location which it is finally to occupy. It is perferable that all wiring should be done before the boxing is removed from the machine, as the boxing will be effective in keeping the machine clean.

As soon as the machine is unboxed, the name plate should be inspected to see that the volts, cycles and phases marked on the name plate of the motor agree with those of the circuit on which the machine is to be used. The name of the generator marking also indicates the volts and ampères which the generator is designed to deliver, and the rating should agree with that specified on the order. It should be remembered that the direct-current arc for motion picture projection requires less current than the alternating-current arc, 25 to 35 ampères at 55 volts being usual for the D. C. arc, corresponding to 40 to 60 ampères at 35 volts for the alternating-current arc.

The A. C. to D. C. Compensarc should be run only on circuits where the variation of either frequency or voltage from normal does not exceed five per cent. Where both frequency and voltage vary, the sum of the variation must not exceed eight per cent.

If for any reason the generator or motor must be taken from the base in order to install the compensarc, great care should be exercised that the machines are properly lined to give a uniform air gap when the compensarc is reassembled. If this is not done, trouble will occur due to the set being

out of line. Dowell pins are provided on the generator end. To remove these hold the squared head of the pin with a wrench and tighten up the nut which will pull out the pin. Be careful that any liners found under the feet are carefully re-

A. C. TO D. C. COMPENSARCS

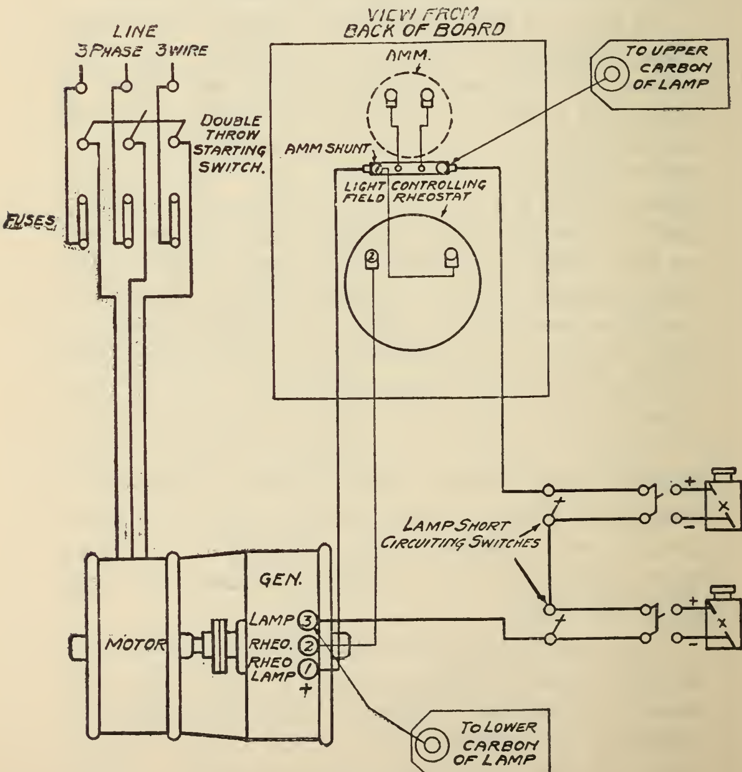


FIG. 291
Connection Diagram for the 50 and the 70-Ampere Lamp Outfit

placed in their proper place. Should the coupling be taken apart, it must be assembled carefully, making sure that the halves fit properly.

Diagram Fig. 290 shows the external connections for the 35 amperes two-lamp series outfit. Fig. 291 shows the external connections for the 50 and 70-ampere two-lamp series outfit, using only a switch between the line and the motor end of the machine on the two-phase and three-phase circuits. The use of a double throw switch having one side fused for running and the other unfused for starting is generally acceptable to the power companies for motors of five horse-power and smaller. If the power companies or the local conditions require a starting compensarc, the motor end of the two and three-phase compensarc should be connected to the line in accordance with the diagrams Fig. 292 and Fig. 293 respectively.

The wiring should be of sufficient size so that the line drop from the machine to the lamp will not exceed one volt, or two per cent of the voltage when the machine is delivering full-load current to the lamp. If too small a wire is used the lamp will be robbed of some of its voltage and give poor light. The lamp side of these machines does not require fuses, as the generators are so constructed that they will protect themselves against overload current when the arcs are short circuited. The motor side of the various machines should be fused as follows:

	Two 35-ampère Lamps Alternately	Two 50-ampère Lamps Alternately	Two 70-ampère Lamps Alternately
	Fuses	Fuses	Fuses
Single-phase 110-volt	80-ampère	100-ampère	120-ampère
Single-phase 220-volt	40-ampère	50-ampère	60-ampère
Two-phase 110-volt	40-ampère	60-ampère	70-ampère
Two-phase 220-volt	20-ampère	30-ampère	35-ampère
Three-phase 110-volt	50-ampère	75-ampère	80-ampère
Three-phase 220-volt	25-ampère	35-ampère	40-ampère

Before starting the set see that it is perfectly clean and that the brushes move freely in their holders and make good contact with the commutator. Be sure that the oil wells are clean and filled. These machines have overflow gauges with hinged caps. The oil wells should be filled through

A. C. TO D. C. COMPENSARCS

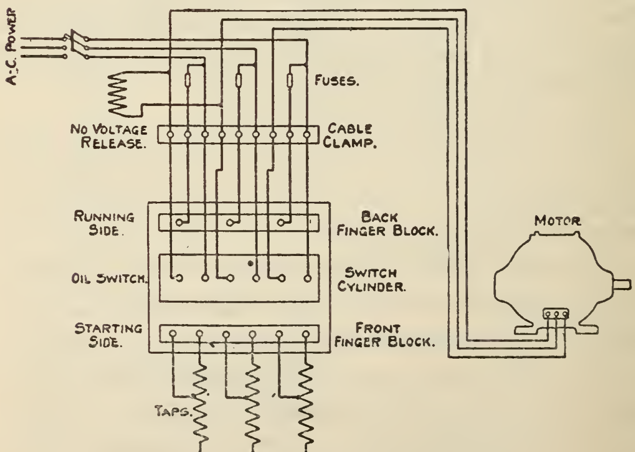


Fig. 292

Connections of Motor End of A. C. to D. C. Compensarc When Compensator Is Used on Three-Phase Circuits

the overflow gauges rather than through the hinged covers in the bearings. This method will prevent waste and annoyance from overflowing of the oil reservoirs. Pour in enough oil to show in the gauges, the thin oil furnished for the moving picture machine, sewing machine oil and similar light oils are not heavy enough. It is better to purchase a can of "light dynamo oil" and keep it for the compensarc.

See that the armature turns freely in the bearings and that the machine is level.

Make sure that all the connections are tight and correspond with the diagram of connections for the outfit supplied.

When starting up see that the armature starts to rotate in the direction marked on the coupling. The direction of rotation of two-phase motors can be reversed by interchanging two line leads of the same phase. In the case of single and three-phase motors it is only necessary to interchange any two line leads of the motor. Immediately after starting, see that the oil rings revolve and carry the oil up to the shaft. Always keep the oil at the proper level in the well, that is, nearly to the lip of the overflow gauge.

STARTING THE COMPENSARC

In starting up the A. C. to D. C. Compensarc, have the switches at the lamps open. If a single-phase outfit, close the main switch and move the starting arm on the starting box from the "off" position to the split segment which will introduce the necessary starting coils to cause the armature

to start to rotate. When the armature has attained nearly full speed, the starting arm should be moved quickly over to the last segment where it is held by a latch controlled by a relay magnet. If the voltage fails, the relay magnet will release the latch, allowing the starting arm to automati-

A. C. TO D. C. COMPENSARCS

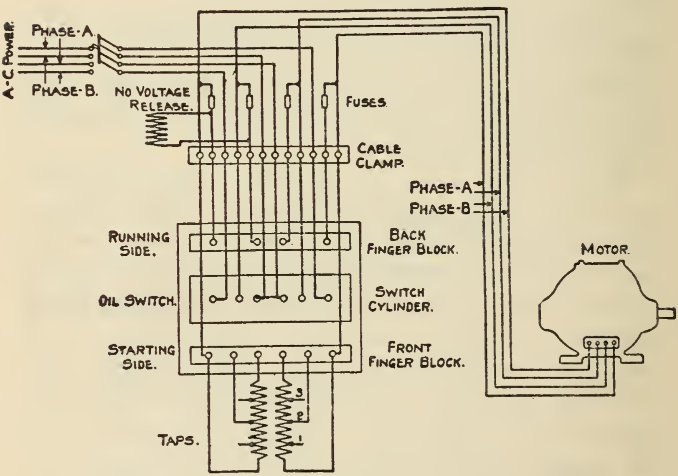


Fig. 293

Connections of Motor End of A. C. to D. C. Compensarc When Compensator Is Used on Two-Phase Circuits

cally return to the "off" position stopping the motor.

The arm of the starting box should never be left in starting position longer than one minute, usually much less time will suffice. When the power companies do not require the use of starting compensators in connection with the two and

three-phase outfits they should be equipped with double-throw starting switches which have only one side fused.

When starting up, the switch should be closed to the unfused side. When the speed of the armature is up to normal the switch should be quickly changed to the running side (fused side).

To start up an A. C. to D. C. Compensarc where a starting compensator is used, see that compensator arm is in the "off" position and close the main switch. The compensator should be thrown into the starting position with a quick, firm thrust and held there until the machine comes up to speed (about 20 to 30 seconds), and then with one quick firm movement the arm should be pulled over into the running position, where it is held by a lever engaging with the low-voltage release mechanism.

Never, in any case, should the motor be started by "touching," that is, by throwing the starting arm into the starting position and quickly pulling it out a number of times. Such a plan of "touching" does not make the rush of current at starting less, but, on the contrary, it produces a number of successive rushes in place of the one which it has been attempted to avoid, and, what is often a more serious matter, causes the contact fingers to be so badly burned that it is necessary to replace them. To stop the machine open the main switch. The compensator arm should automatically return to the "off" position on the opening of the main switch; if it does not, throw it over to the "off" position by hand.

STARTING FIRST LAMP

When the speed of the machine is up to normal and the starting box or switch is in running position and the rheostat handle set as marked by the white arrow, short-circuit the one lamp by means of its short-circuiting switch. Then close the lamp switch and bring the carbons together so that they barely touch; then separate them about 1-16 of an inch, gradually increasing the separation as carbons heat up until the proper length of arc is reached. The D. C. arc should be from 5-16 to 3-8 of an inch long or about twice as long as an A. C. arc. Adjust the generator field rheostat until the proper amount of current is flowing. If the carbons are held together too long the machine voltage will be automatically reduced to zero, so that the arc will not have sufficient voltage, and will therefor break when the carbons are separated. Should this occur, keep the carbons apart about 10 seconds until the machine voltage can automatically build up again, then strike the arc as directed above.

The switchboard panel, having instruments mounted on it along with the field rheostat, is very useful, and the proper current can at all times be accurately maintained. As the machine warms up, the handle of the rheostat may have to be moved one or two buttons from the mark to maintain the desired voltage and current. If the circuits are all connected as shown in the diagram, the polarity should be as indicated, the upper carbon being positive. Should the upper carbon be negative and the instrument on the panel board

read backward, the trouble must be corrected. See that all connections are made as indicated on the diagram. The polarity must come correct if the connections are made in accordance with the diagram of connections, and the armature of the set rotates in the direction marked on the coupling.

STARTING THE SECOND LAMP

To start the second lamp, bring the carbons together to close the circuits; close the lamp switch and open the short-circuiting switch. This puts the two lamps in series, the current from the first lamp flowing through the second lamp. The arc at the second lamp is adjusted in the regular manner while both lamps are burning. When ready to change over from one lamp to the other, bring the carbons of the first lamp together and close its short-circuiting switch, continuing the projection on the second lamp.

It has been found in practice that the following scheme gives the most satisfactory results. A minute or two before the end of a reel of film is reached bring the carbons of the second lamp together, close its line switch and open its short-circuiting switch. The current for the first lamp flowing through the carbons of the second lamp causes the tips of the carbons of the second lamp to heat up to a white heat without actually drawing an arc. Since the tips of the carbons are heated up by this method a normal arc is easily and quickly secured when it is time to change over to the second lamp.

Care must be taken that the two lamps are not both burning any longer than is necessary, as the Compensarc is not intended to carry both lamps continuously. The ammeter on the panel will show the current flowing through the arc when either one or both lamps are burning. The voltage is automatically increased by the machine to

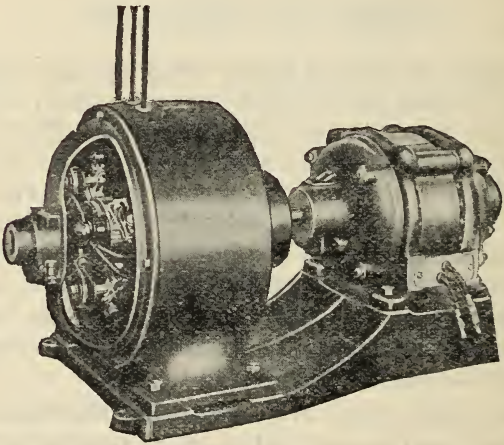


FIG. 294
A. C. to D. C. Compensarc

compensate for the increased drop due to the second lamp and the current is held practically constant.

It is important that all parts of the machine be kept clean. Oil should not be allowed to collect either on the machine or on the floor about it, and the machine should as far as possible be kept free from dust. When the coils of a machine are allowed to become dirty and oil-soaked, it reduces

their insulation strength and eventually causes them to burn out. A small hand bellows will be found convenient for removing the dust from the armature windings.

BEARINGS

The oil-wells should occasionally be cleaned and new oil supplied. They should be filled through

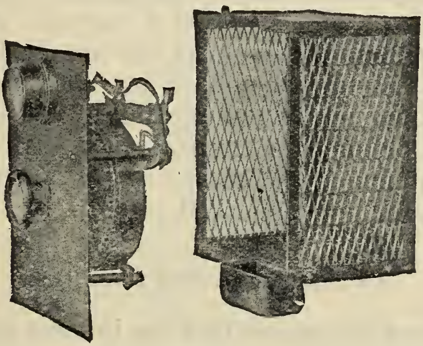


FIG. 295
Special Cabinet Panel with Ammeter and Field Rheostat

the side filling hole, and not through the top of the bearing, for if filled through the top the oil is likely to flow out through the ends of the bearings into the windings. Only good grades of oil free from dust and sediment should be used for poor oil or oil containing sediment will greatly shorten the life of the bearings. Immediately after starting see that the oil rings revolve freely and carry the oil to the top of the shaft. Keep the oil at the proper level in the well, that is, nearly to the lip of the overflow gauge. As soon as the bearing

linings become so worn that the rotor is in danger of rubbing against the stator, a new set of linings should be inserted. To remove the bearings, take out the set screws in the bearing housings, lift the oil rings and drive out the bearings with a wooden block of the same diameter as the bearings. The bearings are a light driving fit in the housing and must be handled carefully. When repair bearings are supplied for the alternating current motors the set screw depression is already in the bearing, but the direct current bearings, which regulate the end play, are supplied without being previously spotted. They must be spotted before being put in place, using a 3-16 inch drill and spot-drilling for the tip of the set screw the same distance from the end of the bearing as is the bearing being replaced.

COMMUTATOR AND BRUSHES

It is very important that the brushes make perfect contact with the commutator, and to secure good contact it is important that both brushes and commutator be kept clean and free from carbon dust and dirt.

To secure proper commutation and proper operation, the brushes must occupy the correct position on the commutator. This proper position of the brush yoke has been determined at the factory while the machine was on test, and is indicated by corresponding chisel marks on brush yoke and frame. It is very important that these marks indicated by white lead should be in line to secure satisfactory operation of the machine.

If the brush holders should become loosened or moved in any way, they must be carefully reset so that they make the proper angle with the commutator as shown in Fig. 296. They must also be so spaced around the commutator that the distance from tip to tip of the brushes is exactly the same. Care should be taken that the brush-holders are

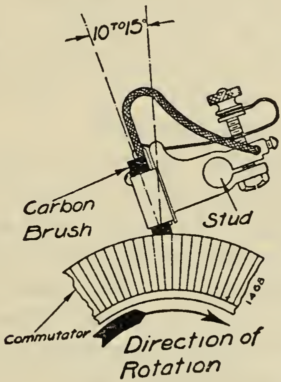


FIG. 296
Showing Correct Method of Setting the Brushes

securely fastened at an even height 1-16 inch above the commutator.

When replacing worn down brushes the new ones should be fitted to the commutator by means of fine sandpaper, carefully pulled under the brush in the direction of rotation, being held tightly to the contour of the commutator. If the brushes are inspected once a week and all gum cleaned away from the brushes so that they move freely in the brush-holders, much longer life of brushes and commutator will result. If the pressure is too

heavy the wear of both brushes and commutator will be excessive, while if the pressure is too light the contact will not be properly made between brushes and commutator and sparking may result; the proper pressure of the springs on the brushes is just sufficient to insure good contact between brushes and commutator. A dirty commutator can be best cleaned by rubbing with a clean cloth saturated with kerosene or machine oil. To keep the commutator in good condition, wipe it from time to time with a piece of canvas lightly coated with sperm or machine oil. Lubricant of any kind should be used sparingly.

If the commutator begins to cause trouble at any time, due to roughness, it should be given immediate attention. Any delay will aggravate the case and may result in undue sparking, heating and consequent troubles. The roughness may be removed by polishing the commutator with a piece of very fine sandpaper by pressing it against the surface of the commutator with a block of wood shaped to the curvature of the commutator face. In using the sandpaper (emery cloth should never be used) it should be moved back and forth along the surface parallel to the shaft to prevent grooving the face of the commutator. When sanding is finished, the commutator surface and brush faces must be wiped carefully to remove any copper dust and grit which may have adhered to them. If the commutator has been allowed to become very rough it may be necessary to grind it down to a true surface, using a small piece of fine sandstone. In using this it should be steadied against the brush holders (properly protected) or

other steady-rest. Brushes should be lifted from the commutator while grinding it. After grinding polish with fine sandpaper.

If the above treatment does not remedy the trouble it will be necessary to tighten the commutator segments and turn down the commutator. The commutator should be trued by taking off the lightest cut possible, using a sharp tool and high cutting speed. Following the operation of turning down the commutator, the mica between the bars should be carefully cut down below the surface of the bars. Next remove the tool marks from the surface of the commutator with very fine sandpaper, and blow all the copper dust and chips from in and around the commutator bars, making a final inspection to see that at no place does the copper dust or chips bridge over the mica from one bar to another. The truing of the commutator should be required only after a long period of service, if the machine has been properly cared for, and should be done only by someone familiar with such work.

D. C. TO D. C. MOTOR-GENERATOR SET

For Projection Arc Control

For 2 Arcs in Series Used Alternately

GENERAL

The D. C. to D. C. motor-generator set consists of two machines, a generator and a motor, coupled together and mounted on a common base.

The sets are shipped completely assembled and require only proper installation, filling of the bearings with oil and proper connection to the supply and lamp circuits before putting into service. Understand that these sets are special machines for use only on picture projection arcs and cannot be used for ordinary constant voltage purposes.

The complete equipment consists of the D. C. to D. C. motor-generator set, proper starting box, two short-circuiting switches (one for each picture machine) and the panel on which is mounted the ammeter and field control rheostat.

INSTALLATION

Install the D. C. to D. C. motor-generator in a clean, dry, well ventilated location and, if possible, near to the lamps which it is to operate. Oftentimes a small room adjoining the projection room is provided for the set, but in some cases where such arrangement cannot be made the machine is installed in the basement of the theatre. Avoid inaccessible locations, as such locations will result

in the machines being neglected, allowed to become dirty and perhaps damaged.

It is not necessary to provide foundations for these machines, but the floor on which they are placed must be firm and free from vibration.

The machines are shipped clamped to a pair of wooden skids which form a foundation for the boxing. If possible, leave the machine attached to these skids until it has been conveyed to the location which it is to finally occupy. It is preferable

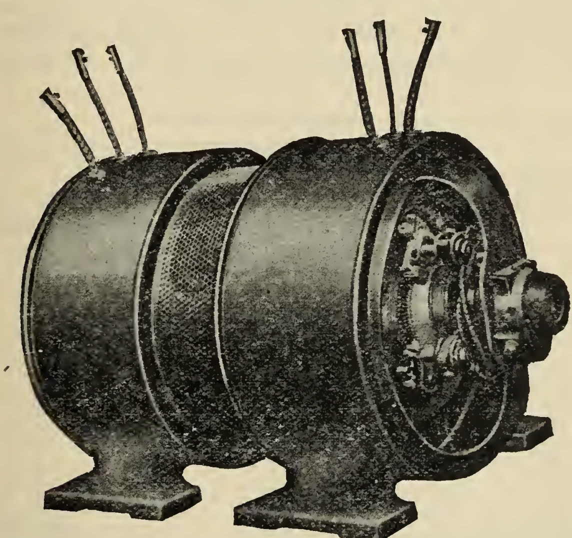


FIG. 297
D. C. to D. C. Motor Generator

that all wiring should be done before the boxing is removed from the machine, as the boxing will be effective in keeping the machine clean.

As soon as the machine is unboxed, inspect the name plate to see that the volts marked on the

name plate of the motor agree with those of the circuit on which the machine is to be used. The marking of the generator name plate indicates the volts and amperes which the generator is designed to deliver and this rating should agree with that specified in the order.

CONNECTIONS

WIRING DIAGRAMS

Diagram Fig. 298 shows the external connections for the 35-ampere two-lamp series outfit and

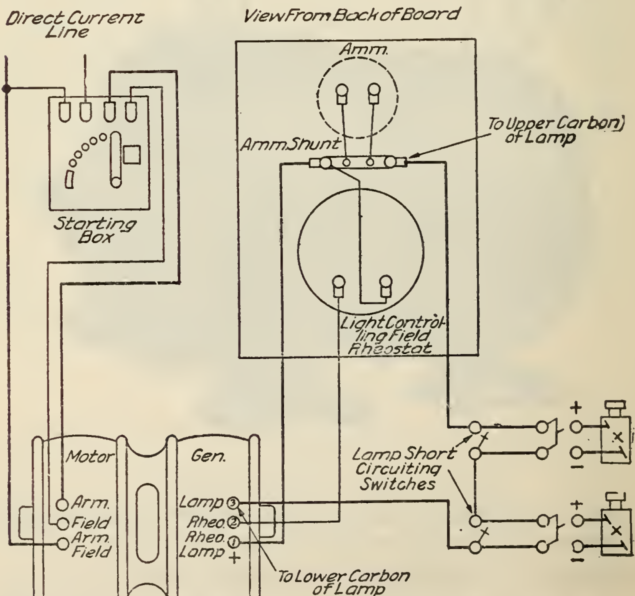


Fig. 298
Connection Diagram for 35-Ampere Lamp Outfit

Fig. 299 shows the external connections for the 50, 70 and 100-ampere two-lamp series outfit.

WIRING

Be sure that the wiring is of sufficient size so that the line drop from the machine to the lamp will not exceed one volt, or two per cent of the voltage when the machine is delivering full load current to the lamp. If too small a wire is used the lamp will be robbed of some of its voltage and give poor light.

D. C. TO D. C. MOTOR GENERATOR SETS

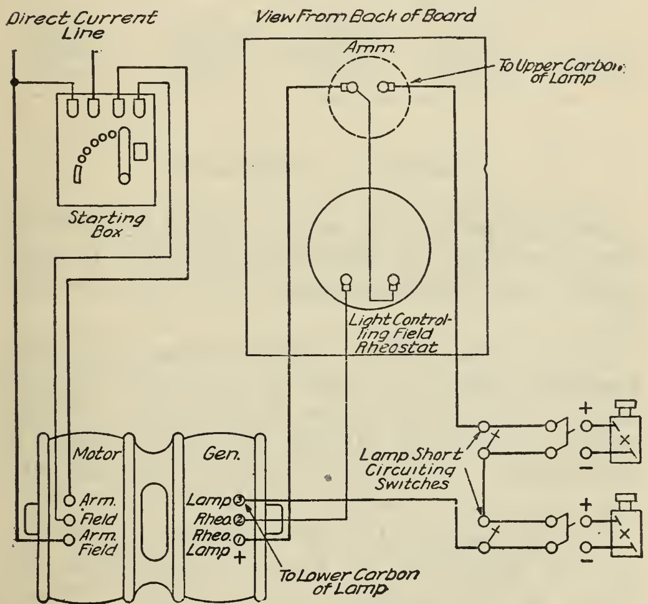


FIG. 299
Connection Diagram for the 50, 70 and 100-Ampere Lamp Outfit

FUSES

The lamp side of these machines does not require fuses, as the generators are so constructed that they will protect themselves against overload current when the arcs are short circuited.

The motor side of the various machines should be fused as follows:

	Two 35-ampère Lamps Alternately	Two 50-ampère Lamps Alternately	Two 70-ampère Lamps Alternately	Two 100-ampère Lamps Alternately
	Fuses	Fuses	Fuses	Fuses
115 volts	60-ampère	80-ampère	120-ampère	160-ampère
230 volts	30-ampère	40-ampère	60-ampère	80-ampère
550 volts	15-ampère	20-ampère	30-ampère	40-ampère

INITIAL STARTING

Before starting the set see that it is perfectly clean, and that the brushes move freely in their holders and make good contact with the commutator.

Be sure that the oil wells are clean and filled. These machines have overflow gauges with hinged caps. Fill the oil wells through the overflow gauges rather than through the hinged covers in the bearings. This method will prevent waste and annoyance from overfilling of the oil reservoirs.

Pour in enough oil to show in these gauges. The thin oil furnished for the moving picture machines, sewing machine oil, and similar light oils are not heavy enough; it is better to purchase a

can of "light dynamo oil" and keep it for the motor-generator.

See that the armature turns freely in the bearings, and that the machine is level.

Make sure that all connections are tight and agree with the diagram of connections for the outfit supplied, so that when starting up the armature will start to rotate in the direction marked on the coupling.

Immediately after starting, see that the oil rings revolve freely and carry the oil up to the shaft. Always keep the oil at the proper level in the well, that is, nearly to the lip of the overflow gauge.

OPERATION

STARTING THE MOTOR-GENERATOR

In starting up the D. C. to D. C. set have the switches at the lamps open. Close the main line switch and move the lever of the starting box to the first contact point holding it there for two or three seconds to allow the armature to start to rotate. Then move the lever slowly over the remaining contact points until it reaches the running position where it will be held in place by the retaining magnet. If the voltage fails the retaining magnet will release the latch allowing the starting arm to automatically return to the "off" position stopping the motor.

To stop the machine open the main switch. The arm of the starting box should then automatically return to the "off" position. If it does not, throw it over to the "off" position by hand.

STARTING FIRST LAMP

When the speed of the machines is up to normal and the arm of the starting box is in running position and the rheostat handle set as marked by the white arrow, short circuit the one lamp by means of its short-circuiting switch. Then close the lamp switch of the other lamp and bring the carbons together so that they barely touch; then separate them about 1-16 of an inch, gradually increasing the separation as carbons heat up until proper length of arc is reached. The D. C. arc should be from 5-16 to 3-8 of an inch long, or about twice as long as an A. C. arc. Adjust the generator field rheostat until the proper amount of current is flowing.

If carbons are held together too long, the machine voltage will be automatically reduced to zero, so that the arc will not have sufficient voltage and will, therefore, break when carbons are separated. Should this occur, keep carbons apart about 10 seconds until machine voltage can automatically build up again; then strike the arc as directed above.

The switchboard panel has an ammeter mounted on it along with the field rheostat and is very useful as the proper current can at all times be accurately maintained. As the machine warms up, the handle of the rheostat may have to be moved one or two buttons from the mark to maintain the desired voltage and current.

If the circuits are all connected as shown in the diagram the polarity should be as indicated. The upper carbon must be positive. Should the upper carbon be negative and the instrument on the panel read backward, the trouble must be cor-

rected. See that all connections are made as indicated on the diagram.

The polarity must come correct if the connections are made in accordance with the diagram of connections and the armature of the set rotates in the direction marked on the coupling.

STARTING THE SECOND LAMP

To start the second lamp bring the carbons together to close the circuit, close the lamp switch and open the short-circuiting switch. This puts the two lamps in series, the current from the first lamp flowing through the second lamp. The arc at the second lamp is adjusted in the regular manner while both lamps are burning.

When ready to change over from one lamp to the other bring the carbons of the first lamp together and close its short-circuiting switch, continuing the projection on the second lamp.

It has been found in practice that the following scheme gives the most satisfactory results. A minute or two before the end of a reel of film is reached bring the carbons of the second lamp together, close its line switch and open its short-circuiting switch. The current for the first lamp flowing through the carbons of the second lamp causes the tips of the carbons of the second lamp to heat up to a white heat at the tips without actually drawing an arc. Since the tips of the carbons are heated up by this scheme a normal arc is easily and quickly secured when it is time to change over to this second lamp.

Take care that the two lamps are not both burning any longer than is necessary, as the motor-

generator is not intended to carry both lamps continuously. The ammeter on the panel will show the current flowing through the arc when either one or both lamps are burning; the voltage is automatically increased by the machine to compensate for the increased drop due to the second lamp and the current is held practically constant.

WESTINGHOUSE MOTOR-GENERATOR

GENERAL INFORMATION

Unpacking. When uncrating the equipment protect the various units against severe shocks and blows, especially if the temperature of the air is very low. Do not remove the blocking between the generator and motor frames until the set is finally installed at its permanent location. Furthermore, these sets should never be moved from their permanent location unless suitable blocking is placed between the motor and generator frames. This is important so as to prevent bending the bearings out of alignment. Be sure to protect all the equipment from moisture and make certain that all windings of the motor and generator are dry before subjecting them to operating voltage.

Location. All of the electrical equipment should be finally installed in a clean, dry, well ventilated place and in such a manner as to be easily accessible for inspection and cleaning. The room or enclosure for the equipment should be sufficiently well ventilated so that the air temperature will never be in excess of 104 deg. Fahrenheit.

Foundation. A foundation should be provided for the motor-generator so that the bottom of the bed-plate will be approximately two feet above the level of the surrounding floor. To prevent the magnetic hum and vibration of the set being transmitted to the surrounding supports such as floor

and walls of the building, it is desirable to build a vibration and sound-absorbing base.

Such a base may be constructed readily with solid planking two inches thick and layers of solid cork each layer two inches thick. Anchor bolts should be placed in the foundation so that they will extend a sufficient distance above the sound-absorbing base to permit the placing of nuts. The supporting foundation should preferably be made of hollow concrete. The cork should be placed in two layers on the concrete foundation. On top of the cork should be placed the plank frame constructed of the two layers of two-inch plank. The planks of one layer should be laid at right angles with the plank in the other, both layers to be bolted or nailed together securely. The anchor bolts must be located so that they will not touch any portion of the motor-generator bed-plate. After the plank frame is in place the anchor-bolt nuts should be drawn up tight. The motor-generator may then be mounted on the plank frame and, if desirable, the bedplate may be bolted down to the plank frame as holes are provided for this purpose. If so desired, heavy felt may be substituted for the cork but cork is much more resilient and will remain elastic indefinitely, whereas felt will not.

When constructing the foundation and sound-absorbing base it is essential that the top of the plank platform be made level so that the oiling system of the motor-generator will not fail after the set is installed.

Throughout this article, equipments for two typical types of installations will be considered

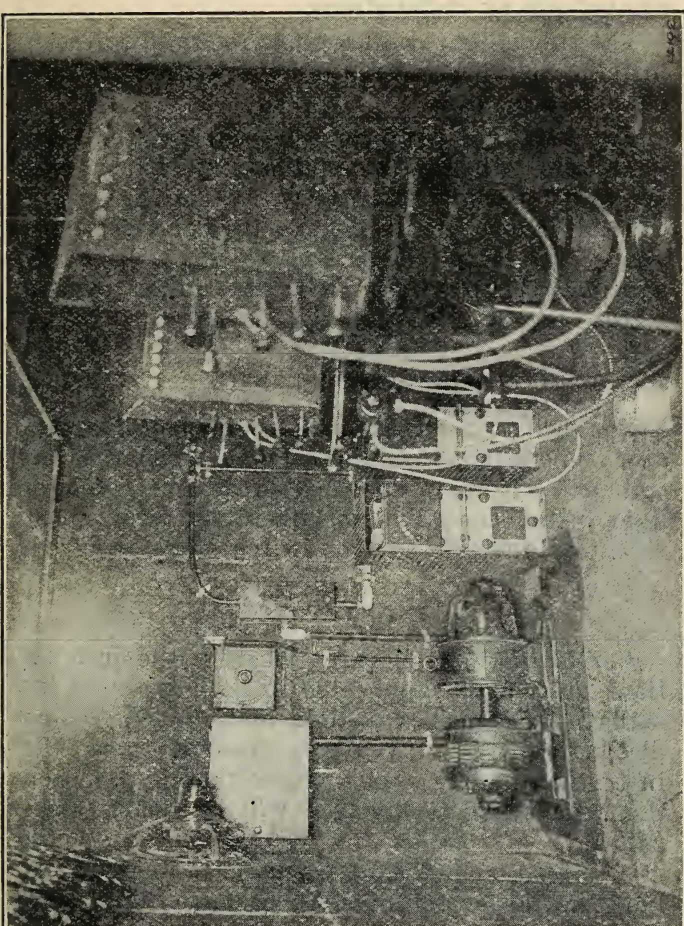


FIG. 300
Westinghouse Generator, Showing Rheostats and Control

under the captions of single light, and two-light equipments or installations.

The single-light equipment is required for each installation wherein only one motion picture machine is to be used.

The two-light equipment is required for each installation wherein two motion picture machines are to be operated alternately, for "change over" or "continuous picture service." For this latter service one lamp is "warmed up" for a period of approximately one minute when another motion picture machine is in operation.

EQUIPMENT REQUIRED

For each single-light installation a motor-generator and one ballast rheostat are required, the control switch being optional; whereas, for each two-light installation, a motor-generator, two ballast rheostats and two control switches are required.

INSTALLATIONS

Foreword. For all cases wherein the instructions are equally applicable to both types of installations, namely, two-light and single-light, no distinction will be necessary. However, when the instructions apply to only one of these types, then the type which is involved will be clearly indicated.

A *control switch* is a single-pole, single-throw knife switch, which must be protected by a suitable cover if mounted on the frame of a motion picture machine. If the control switch is mounted on a switchboard panel, then the individual cover is not required for this switch.

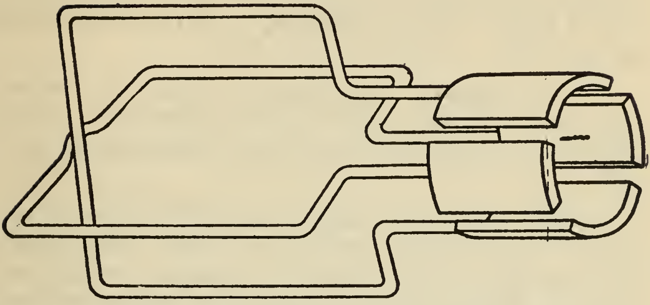


FIG. 301

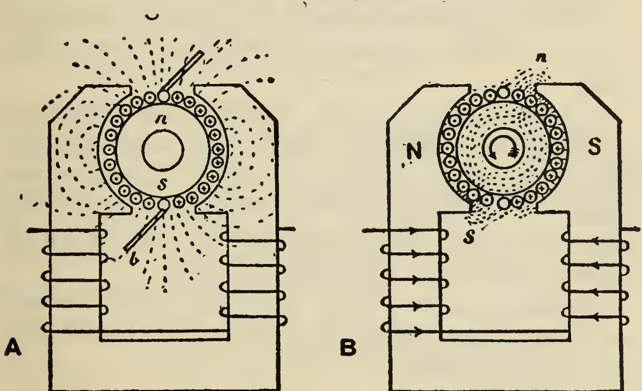


FIG. 302

INSTALLATION

Motor-Generator. Install the motor-generator either in the operating booth, or as near the booth as possible.

Motor Starting Equipment. Install the motor control equipment, for the motor-generator, in the booth, if permissible, or as near the booth as possible.

Ballast Rheostats. Install the ballast rheostats either in or near the operating booth. Each ballast rheostat frame should be mounted so that the three tie rods, passing through and supporting the grids, are horizontal. This places the grids in an upright position which permits a free circulation of air vertically between the grids.

Control Switches. The control switch for each ballast rheostat should, preferably, be mounted on the frame of the motion picture machine, with which the ballast rheostat is to be used, beside the cut-out switch connected to the arc lamp terminals.

Indicating Meters. A suitable direct-current ammeter and voltmeter should be used and connected in the generator circuit. These meters should be installed in the operating booth, in a position where they can be easily seen by an operator when he is projecting pictures.

Switchboard or Panel. A panel should be used on which are mounted the meters, and the generator field rheostat.

WIRING AND CONNECTING MOTOR-GENERATORS

TYPE CS POLYPHASE MOTOR

Connect the motor and auto-starter by referring to the diagram furnished with the auto-starter. If the circuit is 2-phase, 4-wire, connect leads from one phase to motor terminals A1 and A2 and leads from other phase to terminals B1 and B2. If circuit is 2-phase, 3-wire, connect outside leads to terminals A1 and B1 and middle lead to A2 and B2. If circuit is 3-phase connect any lead to any terminal. To obtain proper direction of rotation see instructions below. If fuses are used in the running circuit they should carry current in excess of current indicated in nameplate as follows:

2-phase, 4-wire circuit, all leads, 25 per cent.
2-phase, 3-wire circuit
  outside leads, 25 per cent.
  middle lead, 75 per cent.
3-phase, 3-wire circuit, all leads, 25 per cent.

If circuit-breakers are used in the running circuit they should be adjusted to open the circuit with the above overload capacities.

Fuses in the starting circuit should carry four to five times the rated current.

TYPE AR SINGLE-PHASE MOTOR

Voltages. This motor can be connected for operation on either 110 or 220-volt circuits.

Connections. The diagram shows the connections. The motor is connected directly to the line

through a circuit-breaker or a line switch and fuses.

TYPE SK DIRECT-CURRENT MOTOR

Connections. Refer to the diagram and make the following connections for counter-clockwise rotation looking at the commutator end:

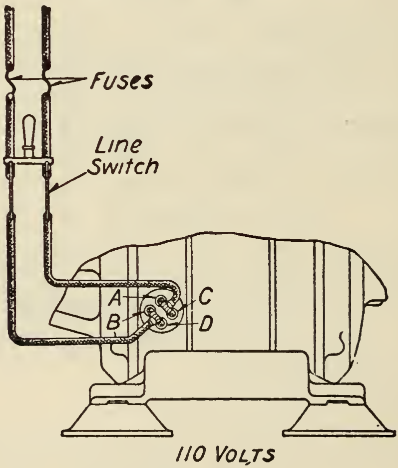


FIG. 303
Diagram of Connection for Type A.R. Motors

Connect A2 to starting resistors, thence to + line.

Connect A1 to S1.

Connect S2 and F2 to — line.

Connect F1 to + line.

WIRING AND CONNECTING EQUIPMENTS

Single Light and Two-Light Equipment. Should be wired and connected as indicated by Fig. 305,

or Fig. 306, if a control switch is used. If a control switch is not used, then the wiring for Fig. 305 should be modified by omitting the leads to the control switch and by connecting a lead from the lower left-hand stud of the cut-out switch to terminal 7 on the ballast rheostat, instead of to terminal 8. Likewise, the wiring of Fig. 306 should be modified by omitting the leads to the control switch and by connecting the lead from the lower right-hand stud of the change-over switch, to terminal 7 on the ballast rheostat.

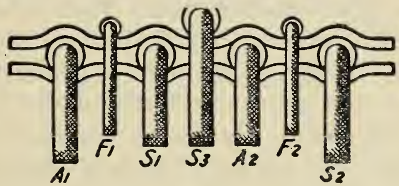


Fig. 304
Diagram of Type S.K. Motor Terminals

TYPE SK GENERATOR

Connections. The diagram and directions below show the connections for clockwise rotation looking at the commutator end:

Connect A1 to + line.
Connect A2 and F2 to S2.
Connect S1 to — line.
Connect F1 to field rheostat, thence to + line.

MINIMUM SIZE OF WIRE FOR INSTALLATION

Single-light. For each single-light installation, wherein the distance from the generator terminals

to the cut-out switch on the motion picture machine, measured along the route of the wiring or conduit, is 300 feet or less, the size of the wire is determined by the current to be carried. (See the "National Electric Code.") If the distance is over 300 feet, the exact distance should be referred to the Company for recommendations as to the proper size of wire to be used.

Two-light. The minimum size of wire to be used for the circuit, which must carry current for both lamps for a two-light installation, is indicated in Table No. I, hereinafter given. The column headed "Length in Feet of Circuit Which Must Carry Current for Both Arc Lamps" represents the distance from the generator terminals to the generator switch, or to the point where the circuit, which must carry current for both lamps, branches or divides into separate circuits, one for each lamp. The distance must be measured along the route of the wiring or conduit. If this distance is greater than 300 feet, the exact distance should be referred to the Company for recommendations as to the proper size of wire to be used. The size of all wires which carry current for one lamp only, will be governed by paragraph 25, but the distance is measured along the route of the wiring or conduit from the cut-out switch on each motion picture machine, to the generator switch or to the point where the branch circuit for each lamp joins the main generator circuit. For example, assume an installation, wherein the length of the circuit, which must carry current for both lamps is 130 feet, and the length of each branch circuit to each

lamp is -30 feet, then if a 2 3-4-kilowatt, 75-volt, 36.7-ampere set is used, it will be observed by reference to Table No. I, that No. 00 wire must be used for the main circuit, whereas No. 6 wire may be used for the branch circuit to each lamp.

For *each two-light* installation, wherein the length of the main circuit, which must carry current for both lamps or wherein the length of the branch circuit to either lamp is greater than 300 feet, a diagram should be prepared which represents the wiring, and the length of each wire should be accurately indicated thereon. This diagram should be referred to the Company for recommendations as to the proper size of wire to be used for each circuit.

Emergency Service. For each installation, wherein alternating current is to be used for emergency service, we strongly recommend that all wiring and switches, which will be used for carrying this current to each lamp, be made of sufficient capacity to carry the alternating current, bearing in mind the fact that, in order to produce the same volume, or candlepower, of light, the alternating current (measured in amperes) must be approximately three times as great as the direct current ordinarily used.

Motor Circuits. The wiring for the circuit of each direct-current or alternating-current motor should be of a capacity such that the speed of the motor will not be appreciably affected by the line voltage drop at any load up to and including 30 per cent overload for a few minutes or 100 per cent overload momentarily.

LUBRICATION

Before starting, fill the oil reservoirs with the best quality of clean dynamo oil; overflow plugs must always be kept open. The old oil should be withdrawn occasionally and fresh oil substituted. The old oil can be filtered and used again.

STARTING THE MOTOR-GENERATOR

General. After the apparatus is properly installed and all wiring is correctly connected, open all of the switches in the generator and lamp circuits; turn the contact arm, on the generator field rheostat to the contact marked "in," and then start the motor as explained below.

TYPE CS POLYPHASE MOTOR

To Start Motor. See that the auto-starter handle is in the off position. Close the circuit-breaker, if one is used, then close the main switch. Move the auto-starter handle from the off to starting position. When the motor attains practically full speed, move handle of auto-starter to running position. Do not leave the auto-starter handle in starting position.

If an auto-starter is not required, the starting switch must be thrown to the starting position until the set operates at almost full speed and then the switch may be thrown to the running position.

TYPE AR SINGLE-PHASE MOTOR

To Start Motor. Close the line switch. The motor starts as a repulsion motor with current

flowing through the brushes and commutator. At nearly full speed a centrifugal governor inside the armature automatically short-circuits the armature windings, thus causing the motor to run as a squirrel-cage induction motor. The brushes are thrown off by the end thrust of the armature. If the motor does not come to full speed, which is shown by continued sparking at the brushes, the motor is overloaded and will overheat. Apparently there is a load on the generator. Look over the generator circuit and make sure that all load is removed by opening all cut-out switches.

TYPE SK DIRECT-CURRENT MOTOR

To Start Motor. See that all instructions for connecting and installing the motor have been complied with and that the handle of the starter or controller is in the "off" position. Close the line switch or circuit-breaker and move the starter or controller handle step by step to the running position. Motors of less than 10 horsepower can usually be brought to full speed in 15 seconds, and the large motors in about 30 seconds; the time, however, varies with the torque required. If the motor does not start when the third step is reached, first open the line switch or circuit-breaker, then move the handle of the controller to the "off" position, and look for overload or faulty connections.

INSPECTION OF OILING SYSTEM

After the motor-generator is started, raise the covers of all bearings and see that all oil rings are

rotating properly and carrying oil up on the journals.

STOPPING THE MOTOR-GENERATOR

TYPE CS POLYPHASE MOTOR

To Stop Motor. Open circuit-breaker or main switch. Move the handle of auto-starter to the off position. If neither circuit-breaker nor main switch is used, the auto-starter may be used to close and open the main circuit.

TYPE AR SINGLE-PHASE MOTOR

To Stop Motor. Open the line switch or circuit-breaker.

TYPE SK DIRECT-CURRENT MOTOR

To Stop Motor. When a starting rheostat is used, open the line switch or circuit-breaker. Never force the starter handle to the "off" position, but allow it to return automatically.

If the motor is to be shut down for a considerable period, open the line switch or breaker.

REVERSING MOTOR-GENERATOR

The rotating element of the motor-generator should revolve in a clockwise direction as observed by viewing the generator end of the set. If this is not the case when the motor is started, then the wiring connections for the motor must be changed.

TYPE CS POLYPHASE MOTOR

To Reverse Motor. To reverse a two-phase, four-wire motor, the two leads of one phase should be interchanged. To reverse a two-phase, three-wire motor, the two outside leads should be interchanged. To reverse a three-phase motor, any two leads should be interchanged.

TYPE AR SINGLE-PHASE MOTOR

To Reverse Motor. The direction of rotation is determined by the position of the brushes and is indicated by a scale on the rocker ring and a pointer on the front bearing bracket. The scale consists of three lines marked RR, N, and RL, respectively. When the rocker ring is turned so that the pointer is opposite RR, the motor will run in a right-hand or clock-wise direction (facing the commutator) ; and when the pointer is opposite RL, the rotation will be left-hand or counter-clockwise. N is the neutral point; the armature will not turn if the pointer is opposite this line. To reverse the motor, therefore, loosen the rocker ring set-screw and turn the rocker ring until the pointer is opposite the line for the reverse direction of rotation.

ADJUSTING THE EQUIPMENT

After the set is running properly, gradually adjust the generator field rheostat until the potential between the generator terminals, as indicated by a reliable voltmeter, is approximately 75 volts.

Single Light. For single-light equipments (see Fig. 305) the control switch, if one is used, should

always be opened and ballast rheostat contact arm moved to extreme right before striking the arc. After the arc is struck and the carbons have been separated, close the control switch and then readjust the carbons until the potential across the arc is between 50 and 55 volts, as indicated by a reliable voltmeter, the terminals of which are connected directly to the carbons in the lamp. If, under these conditions, the current through the lamp, as indicated by a reliable ammeter, is less than required, and no greater than the full load rating of the generator, then the ballast rheostat contact arm should be moved towards the left until the proper current is obtained. The button on which the proper current is obtained should be marked, so that the operator can always place the arm in proper position.

Two Light. For two-light equipments the control switch connected to the ballast rheostat in the circuit of either lamp, must always be opened before striking the arc.

With lamp No. 2 cut off the circuit, open control switch No. 1 and strike the arc in lamp No. 1. After the carbons have been separated slightly, close control switch No. 1, move contact arm of ballast rheostat No. 1 to extreme right, and then readjust the carbons until the potential across the arc is between 50 and 55 volts, as indicated by a reliable voltmeter, the terminals of which are connected directly to the carbons in lamp No. 1. If, under these conditions, the current through lamp No. 1, as indicated by a reliable ammeter, is less than required or less than the full-load rating of the generator, then the contact arm of the ballast

rheostat No. 1 should be moved towards the left one button at a time until the proper current is obtained.

With lamp No. 1 cut off the circuit, open control switch No. 2, move contact arm to extreme right, and strike the arc in lamp No. 2. After the carbons have been separated, close control switch No. 2, and then readjust the carbons until the potential across the arc is between 50 and 55 volts, as indicated by a reliable voltmeter, the terminals of which are connected directly to the carbons in lamp No. 2. If, under these conditions, the current through lamp No. 2, as indicated by a reliable ammeter, is less than required or less than the full load rating of the generator, then the contact arm of the ballast rheostat No. 2 should be moved towards the left one button at a time until the proper current is obtained.

OPERATING THE EQUIPMENT

Single Light. After the adjustments, specified in paragraph 44, have been made, the equipment is operated in the usual manner, which needs no further explanation.

Two Light. After both ballast rheostats have been properly adjusted, as specified in paragraphs 46 and 47, and the crater in the positive or upper carbon in each lamp is properly formed, the entire equipment is ready for operation as hereinafter given.

Insert reel No. 1 in machine No. 1; open control switch No. 1; strike the arc in lamp No. 1, and then separate the carbons slightly, close control

MOTION PICTURE EQUIPMENT

Single Light Schematic Connections

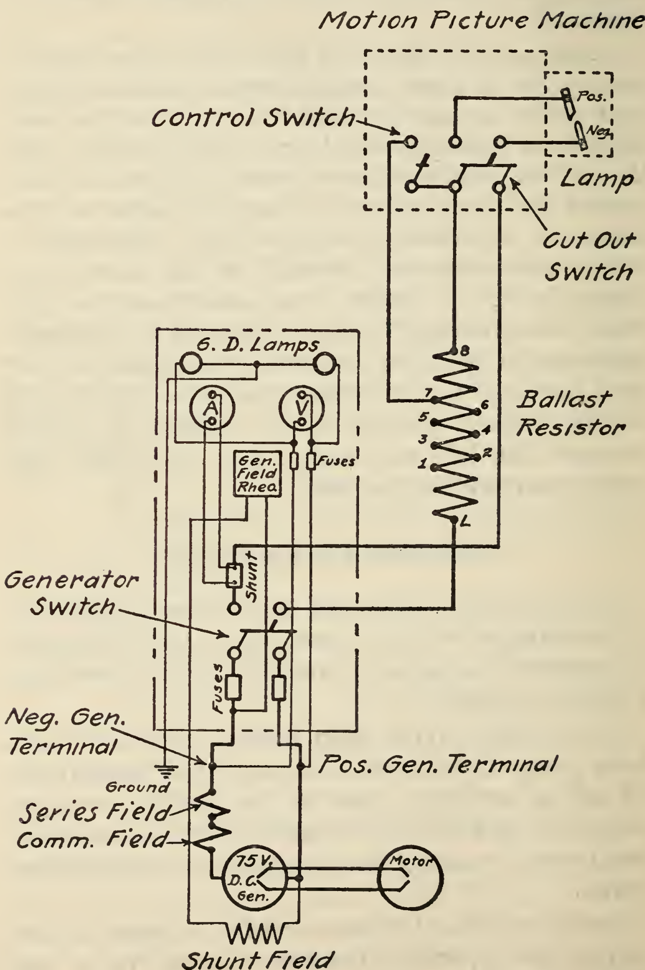


FIG. 305

switch No. 1; adjust the carbons properly and then project pictures in the usual manner.

Reel No. 2 should be inserted in Machine No. 2. About one minute before the end of reel No. 1 is reached, open control switch No. 2; strike the arc in lamp No. 2, and separate carbons slightly. A few seconds before the end of reel No. 1 is reached, close control switch No. 2, and if necessary make a final adjustment of the carbons. At the proper time, as the end of reel No. 1 is reached, begin projecting pictures with machine No. 2, and cut lamp No. 1 off the circuit.

Reel No. 3 should be inserted in machine No. 1. About one minute before the end of reel No. 2 is reached, open control switch No. 1; strike the arc in lamp No. 1 and adjust the carbons properly. A few seconds before the end of reel No. 2 is reached, close control switch No. 1 and if necessary, make a final readjustment of the carbons. At the proper time, as the end of reel No. 2 is reached, begin projecting pictures with machine No. 1 and cut lamp No. 2 off the circuit.

The cycle of operation, as specified in paragraphs 50, 51 and 52, may be carried out indefinitely at the rate of three, four, or five 1000-feet reels per hour, without injury to the electrical equipment, provided each lamp does not require more than the full-load rated current from the generator operating at the potential of 75 volts.

CARE OF MOTOR GENERATOR

TYPE SK GENERATOR AND MOTOR

Commutator. The commutator must be kept clean and the brushes properly adjusted and fitted

to the commutator. Wipe the commutator at frequent intervals, depending on the character of the service, with a piece of clean canvas cloth free from lint. Apply lubricant sparingly; a piece of pariffin rubbed lightly across the commutator surface will furnish sufficient lubrication. No other attention is required by a commutator which is taking on a polish and shows no sign of wear. A rough, raw, copper-colored surface should be smoothed with a piece of sandpaper or fine sandstone ground to fit. In any case the final smoothing should be with fine (No. 00) sandpaper. When using the paper or stone lift the brushes and do not replace them until all grit is removed. Never use emery cloth or emery paper on the commutator.

Brushes. The brushes are set in the neutral position at the factory and the brackets to which they are attached is doweled in position. This adjustment should not be altered, as it is correct for either direction or rotation.

New brushes should be of the same make and grade as those shipped with the machine. Brushes should have only sufficient clearance in the box to slide easily.

TYPE AR SINGLE-PHASE MOTOR

Renewing Brushes. To remove brushes from the holder, turn the rocker ring so that the brushes are brought between the arms of the bearing bracket. Remove the screws of the clips that hold the brushes in place. After inserting new brushes, turn the rocker ring so that the pointer is opposite the line for the proper direction of rotation.

The front bracket of the motor should not be removed unless unavoidable. If the bracket is removed, when replacing make sure that the steel pin in the brush-raising ring enters the corresponding slot in the brushholder casting. Failure to observe this may result in poor operation.

GENERAL POINTERS

Generator Excitation. When a generator is started, it may fail to build up its voltage properly. This may occur even though the generator operated perfectly during the preceding run. This may be due to one or more of the following causes:

(a) Slow speed.

(b) Open shunt-field circuit, caused by faulty connections or defective field coil or field rheostat.

(c) Open armature or commutating-field circuit.

(d) Incorrect setting of brushes.

(e) Reversed series or shunt coils.

(f) Poor brush contact due to dirty commutator or brushes sticking in holders.

(g) Loss of residual magnetism.

Examine all connections; try a temporarily increased pressure on the brushes; look for a broken or burned out resistor coil in the rheostat. An open circuit in the field winding may sometimes be traced with the aid of a magneto and bell; but this is not an infallible test, as some magnetos will not ring through a circuit of such high resistance as some field windings have, even though the winding be intact. If no open circuit is found in the

rheostat or in the field winding, the trouble is probably in the armature. But if it be found that nothing is wrong with the connections or the winding it may be necessary to excite the field from another generator or some other outside source. Calling the generator that we desire to excite No. 1, and the other machine from which current is to be drawn No. 2, the following procedure should be followed:

Open all switches and remove all brushes from generator No. 1; connect the positive brushholder of generator No. 1 with the positive brushholder of generator No. 2; also connect the negative holders of the machines together (it is desirable to complete the circuit through a switch protected by a fuse of about 5 amperes). Close the switch. If the shunt winding of generator No. 1 is all right, its field will show considerable magnetism. If possible, reduce the voltage of generator No. 2 before opening the exciting circuit; then break the connections. If this cannot be done, set the field rheostat contact arm of generator No. 1 on button marked "IN," then open the switch very closely and gradually lengthen the arc, which will be formed, until it breaks.

A very simple means for getting a compound-wound machine to pick up is to short-circuit it through a fuse having approximately the current capacity of the generator. If sufficient current to melt this fuse is not generated, it is evident that there is something wrong with the armature, either a short circuit or an open circuit. If, however, the fuse has blown, make one more attempt to get the machine to excite itself. If it does not

MOTION PICTURE EQUIPMENT

Single Light Schematic Connections. Panel Provided for Emergency Service

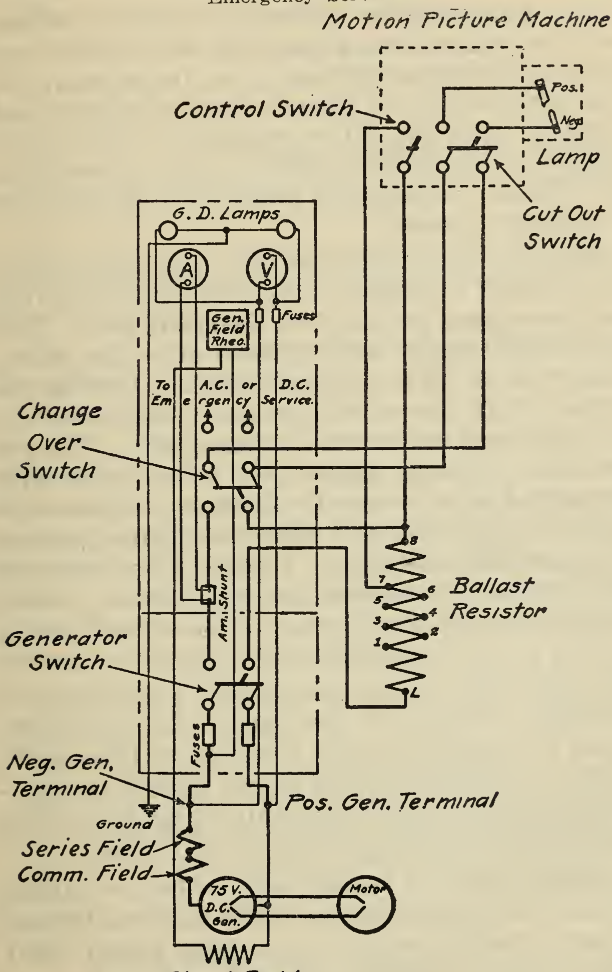


FIG. 306

pick up, it is evident that something is wrong with the shunt winding or connections.

If a new machine refuses to build up voltage and the connections apparently are correct, reverse the field connections; i. e., interchange the field wires which are connected to the positive and negative terminals of the generator. If this interchange of connections does no good, re-establish the original connections and locate the fault as previously advised.

Brushes. All brush faces resting on the commutator should be fitted to the commutator so that they make good contact over the entire area. This can be most easily accomplished after the brush-holders have been adjusted and the brushes inserted. Lift one set of brushes so that they will not be forced against the commutator. Place a piece of sandpaper against the commutator with the sanded side towards the brushes. Replace one brush in its holder and allow the spring to force it against the sandpaper. Draw the sandpaper in the direction of rotation under the brush, releasing the pressure as the paper is drawn back, being careful to keep the ends of the paper as close to the commutator surface as possible and thus avoid rounding the ends of the brush. After the first brush is properly ground, it should be lifted sufficiently to prevent it being forced against the commutator, after which the remaining brushes of the set may be similarly ground one at a time.

By this means a satisfactory contact is quickly secured, each set of brushes being similarly treated in turn. If the brushes are copper plated, their edges should be slightly beveled, so that the cop-

per does not come in contact with the commutator.

Make frequent inspection to see that:

(a) Brushes are not sticking in holders.

(b) Pig-tail shunts are properly attached to brushes and holders.

(c) Tension is readjusted as the brush wears.

(d) Copper plating is cut back so it does not make contact with commutator.

(e) Worn-out brushes are replaced before they reach their wearing limit and break contact with the commutator.

(f) Any free copper picked up by the face of the brushes is removed.

Commutator. The commutator is perhaps the most important part of the machine in that it is most sensitive to abuse. Under normal conditions, it should require little attention beyond frequent inspection. The surface should always be kept smooth, and if, through extreme carelessness, neglect or accident, it becomes badly roughened, the armature should be removed and the commutator turned down in an engine lathe.

Sparking at the brushes may be due to any one of the following causes:

(a) The machine may be overloaded.

(b) The brushes may not be set exactly on the neutral position. If so, the neutral should be determined by running the machine in both directions of rotation and obtaining the same voltage at full load current in both directions.

(c) The brushes may be welded in the holders or have reached their limit of wear.

(d) The brushes may not be fitted to the surface of the commutator.

(e) The brushes may not bear on the commutator with sufficient pressure.

(f) The brushes may be burned on the ends.

(g) The commutator may be rough. If so, it should be smoothed.

(h) A commutator bar may be loose or may project above the others.

(i) The commutator may be dirty, oily or worn out.

(j) The carbon brushes may be of an unsuitable grade.

(k) The brushes may not be equally spaced around the periphery of the commutator.

(l) Some brushes may have extra pressure and may be taking more than their share of the current.

(m) The contact between some brush pigtails and brushholders may be poor, forcing the other brushes to carry too much current.

(n) High mica.

(o) Vibration or chattering of the brushes.

These are the more common causes, but sparking may be due to an open circuit or loose connection in the armature. This trouble is indicated by a bright spark which appears to pass completely around the commutator, and may be recognized by the scarring of the commutator at the point of open circuit. If a lead from the armature winding to the commutator becomes loose or broken it will draw a bright spark as the break passes the brush position. This trouble can be readily lo-

cated, because the insulation on each side of the disconnected bar will be more or less pitted.

The commutator should run smoothly and true, and have a dark glossy surface.

Heating of Field Coils. Heating of field coils may result from any of the following causes:

(a) Too low speed.

(b) Too high voltage.

(c) Too great forward or backward lead of brushes.

(d) Partial short-circuit of one coil.

(e) Overload.

Heating of Armature. Heating of armature may result from any of the following causes:

(a) Too great load.

(b) A partial short-circuit of two coils heating the two particular coils affected.

(c) Short-circuits or grounds in armature winding or commutator.

(d) Bad commutation with consequent large circulating currents in armature coils undergoing commutation.

Heating of Commutator may result from any of the following causes:

(a) Overload.

(b) Sparking.

(c) Too high brush pressure.

Bucking is the very expressive term descriptive of the arcing between adjacent brush arms. In general, bucking is caused by excessive voltage between commutator bars, or by abnormally low surface resistance on the commutator between brush-

holders of opposite polarity. Any condition tending to produce poor commutation increases the danger of bucking. Among other causes are the following:

(a) Rough or dirty commutator.

(b) A drop of water on the commutator from the roof, leaky steam pipes or other source.

(c) Short-circuits on the line producing excessive overloads.

GENERATOR TROUBLES, THEIR CAUSES AND REMEDY

Methods for Locating and Repairing Break in the Armature of Generator

A break in an armature must be located by the fall of potential method, which means that a current must be sent through the armature and the voltage tested across the various segments. First disconnect all the leads from the armature and lift all brushes except one on each pole, then connect the battery to these brushes through the resistance and ammeter shown in Fig. 307, connect the detector to one brush, and then to each segment in turn with a wire from the other terminal of detector until the break is located.

If the two wires from the detector are connected to the segments that the brushes are standing on, a deflection will be seen caused by a fall of voltage through the coils. If we gradually draw the movable wire over the segments towards the other brush, the deflection will gradually fall to zero, providing it is on the side on which the break does not occur (Fig. 307). If, however, the wire is drawn over the segments on the other side, the deflection on the instrument will remain constant until the failing segment is reached, when the deflection will drop to zero as the wire passes over the break.

Instead of moving the testing wire around the commutator, a course that might not always be convenient, it could be held stationary against the

commutator, say a few segments from one of the brushes, and the armature gradually pulled around till the break appeared.

In this case on the unbroken side a constant deflection will be obtained till the break passes a brush, when the needle will fall to zero. On the other side there will be no deflection till the break passes one of the brushes. So long as the break

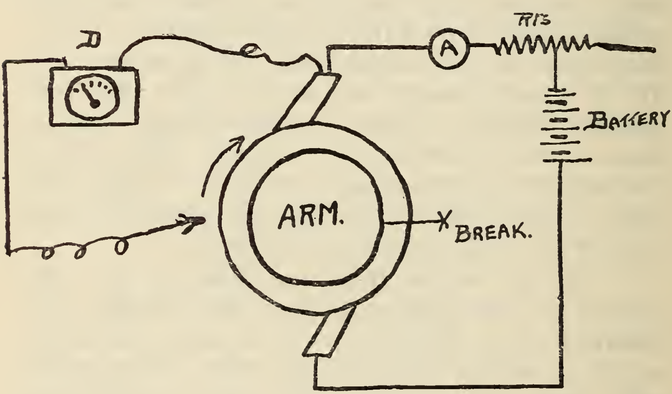


FIG. 307

is between the movable testing wire and the brushes to which the detector is connected, there is a deflection; but not when the break is between the fire brushes and the testing wire. If the instrument gives a good reading between two adjoining segments, it will show a much larger reading across a break.

If a millivoltmeter is available, the matter is somewhat simplified, as a small current is suffi-

cient for testing, such for instance as the current taken by an incandescent lamp. If, therefore, the armature be connected to a source of supply through a lamp, a millivoltmeter will give a good deflection across a break. Millivoltmeter is the instrument used as a shunted ammeter in conjunction with various law resistances called shunts; when used as a millivoltmeter in the manner above described, it is used alone, the armature itself taking the place of the shunt (Fig. 308).

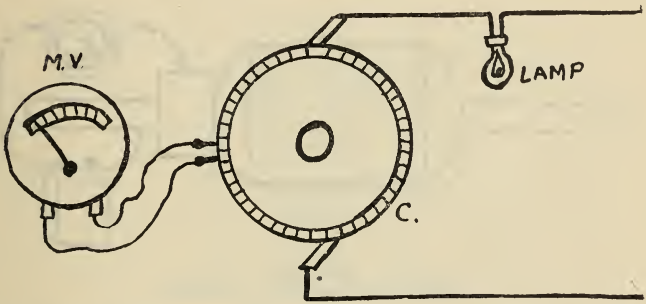


FIG. 308

Having found the broken section it must be examined till the actual break is discovered. In the case of a winding, the bad section can be taken out and a new one put in without much difficulty. In the case of a formed wound drum, it is generally an inaccessible bottom wire that breaks. In this case it is usual to strip the armature till the break is reached; this is not always necessary. Having found the defective section, cut out as

much as can be got at, that is the conductors on the surface of the core or in the slots. Leave the end crossing wires in, but with the ends separated and rewind the section with the end crossings on top of the others.

Overheating the Armature

Several causes will cause overheating of the armature, the most common being—overload, grounds, eddy currents in the core, eddy currents in the conductors, short-circuit in the coils, spark-

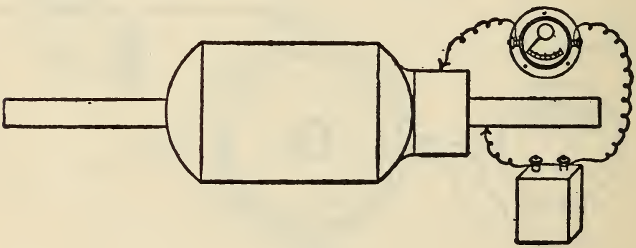


Fig. 309
Insulation Tests for Armature

ing at the commutator, heat conducted from the bearings, low insulation. If the excessive heating is uniform over the whole armature, the machine is overloaded.

Should one or two of the coils be overheated, the trouble is due to a short circuit in the winding. If the core is hotter than the coils, the trouble is due to excessive eddy currents in the laminations, caused by the core rubbing up against one of the pole faces, or it may be caused by a number of the laminations being short-circuited, the slots having been filed too much when the core was built.

Heating due to eddy currents either in the armature core or the conductors, cannot be remedied by the projectionist, the maker of the machine should be immediately notified. The test is to run the generator on open circuit and take note of the rise in temperature. To test for a ground in the windings, first disconnect the generator from the circuit, and then run it up to normal speed. Using an ordinary test lamp, touch the opposite brushes to make sure you have the voltage.

Then connect the lamp terminals between the

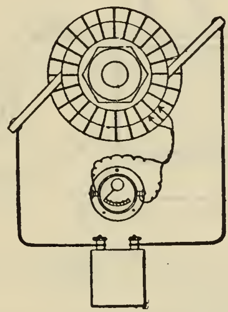


FIG. 310

generator frame and the poles. Should there be a ground the test lamp will either glow or light. The cause of the ground should then be located and removed.

LOCATING GROUND COIL

To locate a grounded coil is a difficult job, and should not be undertaken by anyone who is not familiar with electrical apparatus.

The armature should be removed from the field and set on trestle, a current (not to exceed the normal current of the dynamo) should be passed through the armature from any one of the commutator segments to the shaft. A compass should be held near the conductors, and the needle will be deflected in a certain direction due to the flow of current. If the armature is slowly turned

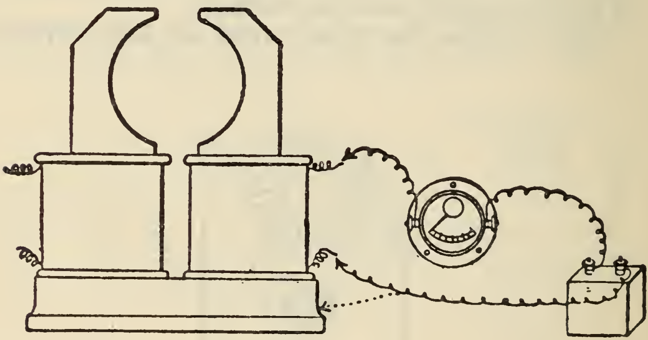


FIG. 311
Field Testing for Continuity and Insulation

round, till such time as the compass needle reverses, this will indicate the proximity of the grounded coil.

Low insulance (insulation resistance) between the core and the armature winding, is generally caused by the presence of moisture, and often accompanied by vapor arising from the armature. This can be remedied by baking the armature in an oven at a temperature of about 200° F, or by running the machine unloaded for a few hours and sending a small current round the windings.

The short circuiting of the coils is generally accompanied by heavy sparking and a smell of burning may be caused by copper dust, oil on bits of solder lodged between the commutator arms.

LOCATING SHORT-CIRCUITED COIL

To locate a short-circuited coil, use the same

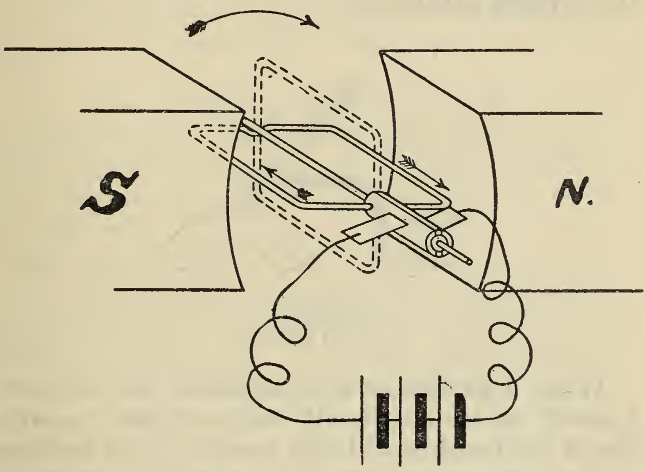


FIG. 312
Principle of Drum Armature Motors

method to locate break in armature. It is best to test between each pair of segments, remembering that the readings will all be alike when connected across the good coils, and that a variation in the reading points to a fault.

The remedy for a short circuited coil is to strip the damaged parts and rewind.

A temporary repair job can be accomplished by disconnecting the short circuited coil from the commutator arms, and then bridging the arms, thus cutting out the defective coil.

Should the short circuiting of the coils be due to copper dust, oil, etc., between the commutator arms, all that will be necessary will be to dislodge the foreign substance.

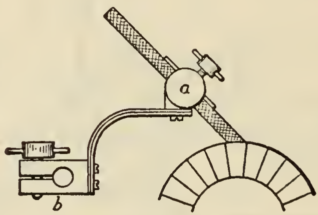


Fig. 313
Brush Holder

When a generator is overloaded, the temperature of the armature will rise, and heavy sparking of the brushes will also result. If the machine is run without removing the overload, the insulation of the armature may be destroyed.

OVERHEATED BEARINGS

A hot bearing may result from one or more of the following causes: Insufficient lubrication, faulty lubrication, grit or other foreign matter in the bearings; armature not centered with respect to pole pieces; side pull due to magnetic pull on

armature; end pressure of collar against the bearing—due to machine being out of line, with its driving shaft, or to want of alignment in engine; to a bent armature shaft; shaft rough or cut, etc., etc.

Only the best of oil, free from sediment and grit, should be used for lubrication, the ordinary machine oil supplied and used on the projector is too thin for this class of work, all the oil cups should be kept clean and filled, the oil rings should be watched to see that they carry the oil up to the shaft.

When the heating of a bearing is due to the presence of dirt or grit, it should be cleaned with some thin oil or kerosene. If kerosene is used, do not forget to use a good lubricant directly after the cleansing.

The bearing caps should just be tight enough to run freely, without any side play. If a bearing is too tight the oil cannot get through as the oil passage remains full. The same thing occurs if the oil passages become choked with dirt or grit.

Do not tighten up the bearing caps with pliers, as sufficient pressure can be brought to bear with the finger and thumb. After tightening up the caps the armature should revolve freely, and when in motion the armature should come gradually to rest. Should the armature stop quickly the bearings are too tight.

A bent shaft will cause the armature to rub pole pieces, and thus produce sparking, vibration and overheating. To overcome this it will be necessary to remove the armature from the machine and have the shaft straightened in what manner

is most handy. It may be found necessary to withdraw the shaft from armature before this can be accomplished.

A rough shaft may be caused by dirt, grit or overheating. The roughness, if not excessive, can be taken out by the use of a little emery cloth, but care should be taken to remove all grit and filings when the job is finished. If the roughness is so great that it cannot be taken out with the use of emery cloth, it will be necessary to remove the armature, and smooth up the shaft in a lathe, using a very fine file and emery cloth.

Noise in a generator can be laid to one of the following causes: Bent or broken shaft; armature out of balance; brushes grinding commentator; armature hitting pole pieces; loose bearings. All screws and bolts should be periodically gone over and any loose one tightened. If the noise is due to the armature not being properly balanced, the makers of the machine should be notified, as this is due to faulty construction of the generator.

A grinding or squeaking noise from the brushes can sometimes be stopped by the application of a very little vaseline to the commutator. If, however, the noise continues, the brushes should be removed and examined to see that a "hard place" has not developed. Should this be the case, the brushes should be filed down past the "hard place" and then replaced in the holders.

In the event of a short-circuit a fuse would naturally blow, and all generators should be fused up as near the terminals as possible.

A series-wound generator would spark and pull the engine up. It would not give any current to the arc.

A compound-wound generator would spark and show a drop in voltage.

A shunt-wound generator would lose its field and would not excite till such time as the short was removed.

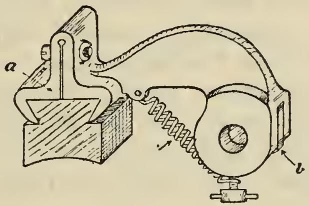


FIG. 314

MERCURY ARC RECTIFIERS

The Mercury Arc-rectifier consists of a transformer, regulating reactance, a tube, control mechanism, and an automatic starting device. The transformer reduces the line voltage to the arc-voltage, the tube acts as a controlling device and prevents the flow of current in the wrong direction. The automatic starting device and remote control allow the apparatus to be installed outside the projection room. Mercury arc-rectifiers are made in 30, 40 or 50 direct current amperes capacity and can be used for service on any commercial alternating current source of supply.

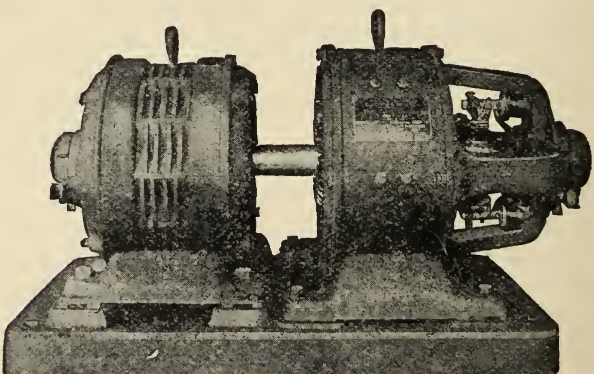


FIG. 315

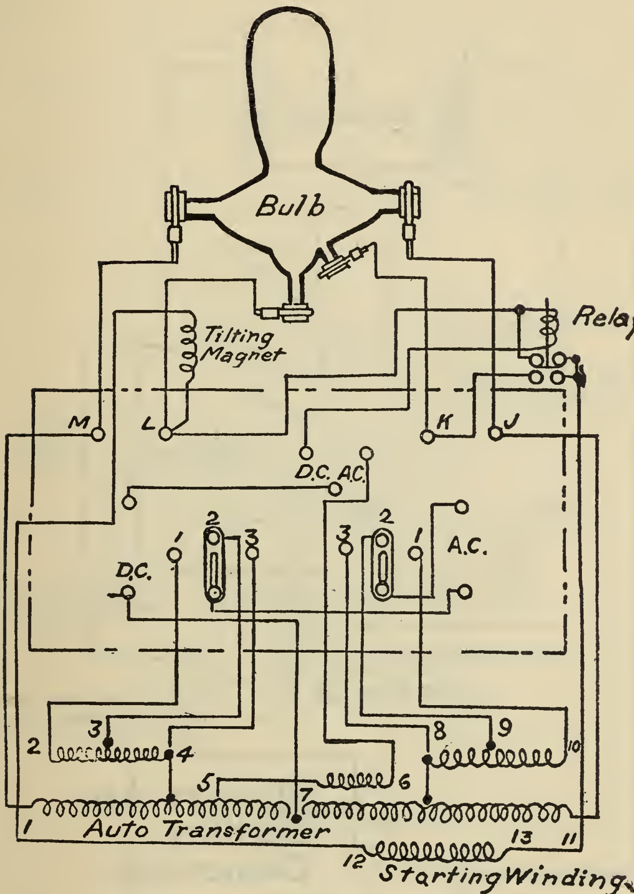

Bulb
Relay
Tilting
Magnet
M
L
K
J
D.C.
A.C.
2
1
3
3
2
1
A.C.
D.C.
3
2
4
5
6
7
8
9
10
1
Auto Transformer
13
11
12
Starting Winding

FIG. 316

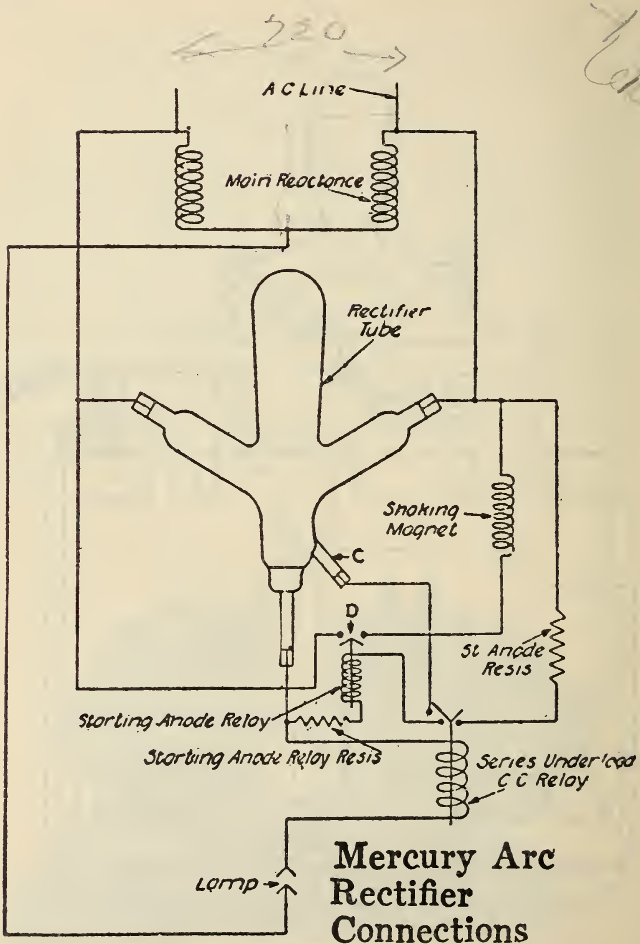

220
A C Line
Main Reactance
Rectifier Tube
Shaking Magnet
C
D
St Anode Resis
Starting Anode Relay
Starting Anode Relay Resis
Series Underload C C Relay
Lamp
Mercury Arc Rectifier Connections

FIG. 317

The bulb is filed with mercury vapor. No current will flow till the starting electrode resistance has been overcome by the conization of the vapor in its neighborhood. To accomplish this, the voltage is raised sufficiently to cause the current to jump the gap between the mercury cathode and the starting cathode, or by bringing the cathode and starting electrode together in the vapor by tilting and then separating them, thus drawing

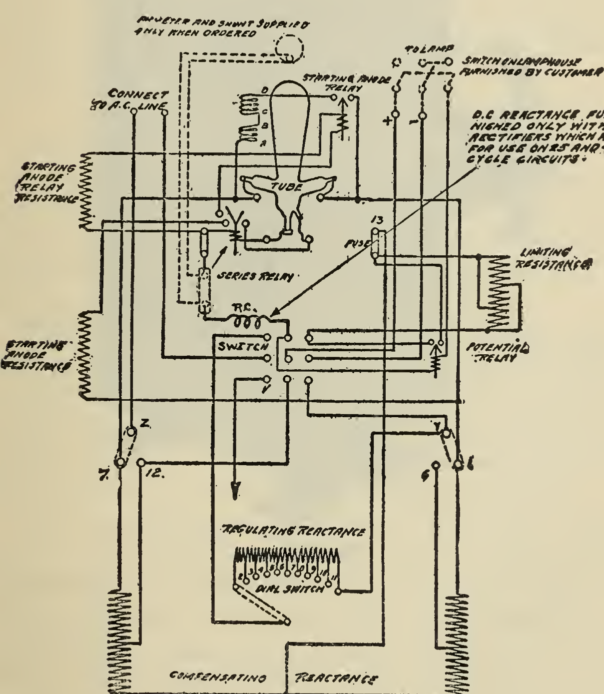


FIG. 318

out the arc. When this has been done current will flow from the anode to the mercury cathode and not in the reverse direction. In order to maintain the action a lag is produced in each half wave by the use of a reactive or sustaining coil, hence the current never reaches its zero value otherwise the arc would have to be restarted.

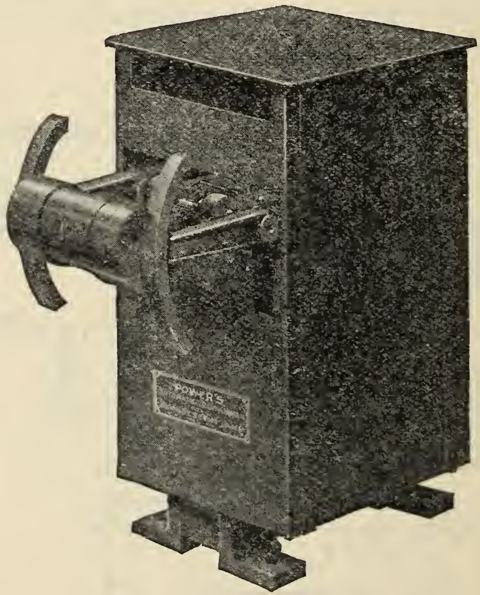


FIG. 319

INSTRUCTIONS FOR THE INSTALLATION OF THE "IMSCO" 1 K. W. MOTION PICTURE PROJECTING AND 32 VOLT INCANDESCENT LIGHTING PLANT

Carefully remove the sides and top of the crate in which the engine is packed, leaving the outfit fastened to the wooden skids, which should not be removed. Transport Engine and entire equipment to point at which it is to be used and then proceed as follows:

PREPARE STORAGE BATTERY FOR SERVICE

Carefully unpack battery, and remove the red soft rubber nipples and discard them. Next remove black hard rubber vent plugs, which are standard equipment, and remain on battery in service.

The battery cells should at once be filled to bottom of vent hole with 1.285 specific gravity electrolyte at 70° F. This electrolyte may be shipped with the outfit, but if not, you will receive sulphuric acid and distilled water separately and you may proceed to mix the electrolyte as follows:

Pour a quantity of distilled or pure rain water into a clean wooden container. Do not use a metal container for either water, acid, or electrolyte, or the electrolyte will be of no use. Next pour very carefully into the water enough sulphuric acid to bring the specific gravity of the mixture to 1.285 by the hydrometer. You will find the hydrometer with the outfit and to adjust it for service, un-

screw the tube carefully, and remove the package in the glass tube. Remove the cardboard from the hydrometer scale, replace it in the glass tube, and screw the rubber tube back in place again. To test the electrolyte simply draw some of it into the glass tube and hydrometer will show the specific gravity reading. Always remember that after

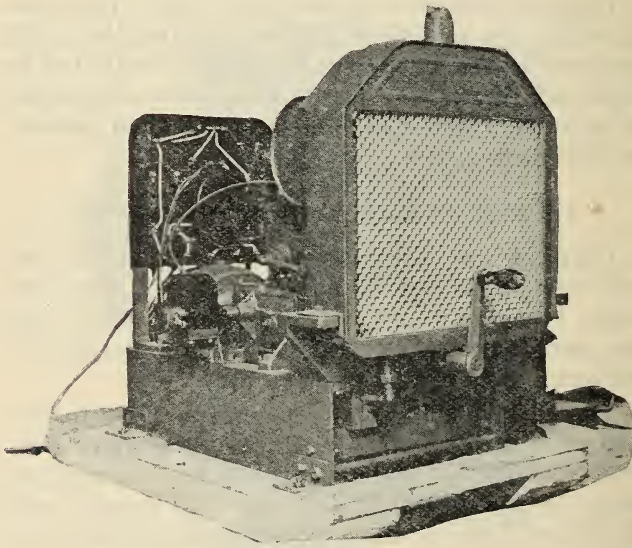


Fig. 320
Imsco Engine and Generator

testing battery cells in this manner the electrolyte taken out should be returned to the cell after reading is taken. Before testing the new electrolyte, thoroughly stir it to make sure it is well mixed and should you find that you have added too much sulphuric acid and the reading is too high, add

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distilled water until the reading is 1.285. Never pour water into sulphuric acid (pure) or you will likely be a fit subject for the hospital. Always pour the acid into the water. Also never stir the electrolyte with anything but a clean wooden stick or the mixture will be ruined.

When sulphuric acid is poured into water the temperature of the mixture will be raised by the chemical action to a very high degree and it should be allowed to cool to between 70° and 90° F. before it is put in the cells. Electrolyte above 90° F. will damage the cells. Do not pour electrolyte into the cells through a metal funnel or you will ruin both electrolyte and battery. No metal of any kind must come in contact with either. Also under no circumstances use any water other than distilled or pure, clean rain water, caught in a wooden container. Tap, well, or river water will contain foreign matter that will damage battery.

BATTERY AND SWITCHBOARD CONNECTIONS

After having prepared the batteries for service, they should be properly connected to the switchboard in the manner shown in the accompanying diagrams. Referring to diagram A (Fig. 322) it will be noticed that there are three wires from the battery to the three right hand terminals on the bottom of the switchboard. It is important that the connections be made as shown and to prevent confusion the three lugs on the end of the three wires supplied have different irregular surfaces, making it impossible to attach any of them to the wrong terminal.

The batteries are shipped in two units of eight

cells each and these units must be connected in series, as shown in the diagram, with the short wire supplied for this purpose, and in the exact manner shown. That is to say, one end of the short wire must be connected to the white, or —

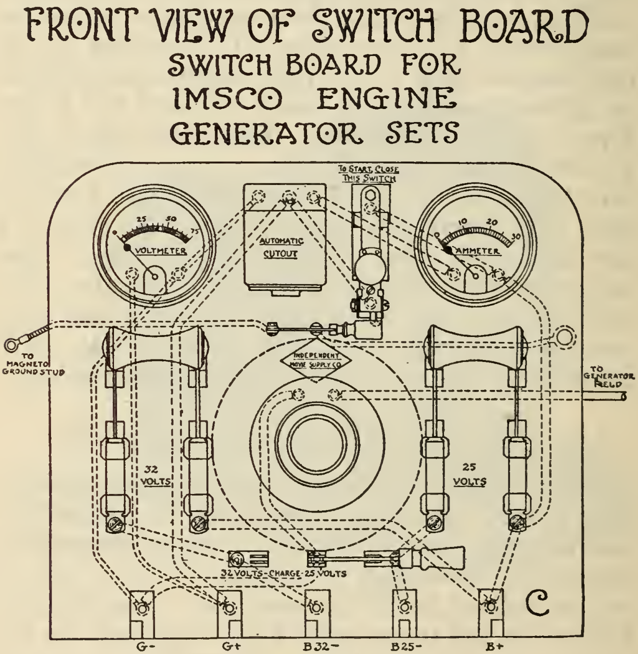


FIG. 321

terminal of one set of cells and the other end of the wire to the red, or + terminal of the battery, the second wire to the white, or — terminal of the twelfth cell of the battery, and the third wire to the other white — terminal at the last cell of the

battery. See that all connections of all the cells are tight. After the batteries have been filled with electrolyte and connected as shown they are ready for charging.

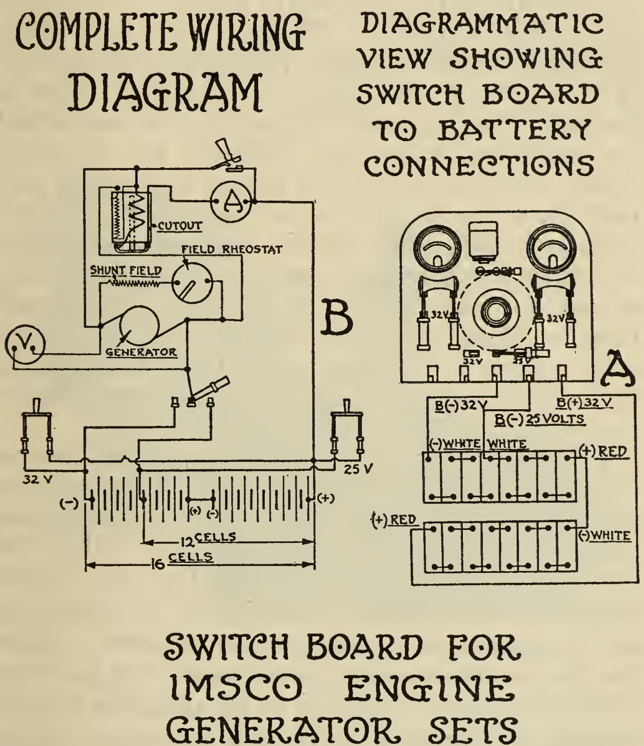


Fig. 322

Diagram B (Fig. 322) shows the complete wiring diagram and it will be seen that the right hand switch, because it is connected across only 12 cells

of the battery, delivers current at 25 volts and this switch only should be used for the Motion Picture T29, 30 ampere lamp. Do not connect this lamp to the other switch or it will immediately burn out. The left-hand switch, because it is connected across the entire battery, or 16 cells, will deliver current at 32 volts and this switch therefore should be used for incandescent lighting of the huts or buildings, or wherever light is needed. To this switch also may be connected any electrical apparatus designed for 32 volts, which does not consume a larger amount of current than the generator is designed to deliver. That is to say, 1,000 watts. Any apparatus that consumes a greater amount than 1,000 watts may be used for a short time but part of the energy will then be taken from the storage battery. When this is done the battery must be again brought up to its proper specific gravity as set forth under the heading "Charging the Battery."

Diagram C (Fig. 321) shows the connections on the back of the switchboard and this should be studied so that you are familiar with what takes place when the outfit is in operation. When the motion picture lamp is in operation the double throw switch should be in the 25 volt position and the ammeter should read 30 amperes. When the double throw switch is in the 25 volt position, it will be seen by referring to the diagram that no current is charged into the four last cells. These cells will therefore become discharged if a large number of incandescent lamps are used when the double throw switch is in the 25 volt position. To overcome this, when the outfit is not being used for projection purposes, throw the switch

into the 32 volt position and charge the battery until all the cells come up to the required specific gravity. (See "Charging the battery.") Always have switch in 32 volt position when using incandescent lamps only, or any 32 volt apparatus.

At the top of the switchboard, in the center, will be seen the automatic cutout which automatically disconnects the battery from the Generator should the Engine for any reason stop. The reason for

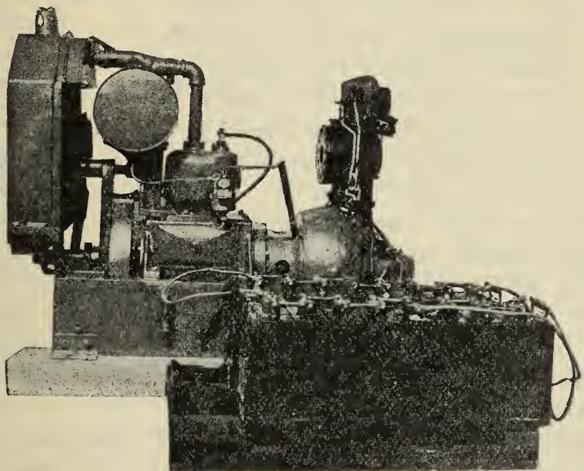


Fig. 323
Showing Battery Connections

this piece of apparatus is that, should the gasoline give out or should any other circumstance happen that would normally stop the engine, it would continue to operate because the Generator would operate as a motor, taking current from the battery. This would in a short time completely discharge

the battery and the Automatic cutout is therefore inserted in the Battery circuit as a safeguard against this trouble.

Before starting the engine observe and carefully carry out the following six instructions:

1. See that Radiator is filled with clean water (it will take 11 quarts) when the weather is above freezing (32° F. or 0° C) and when there is danger of water freezing it should be replaced at once with the following solution:

Glycerine—2 parts by volume.
Water—8 parts by volume.
Denatured Alcohol—1 part by volume.

This solution will not freeze at 20° below zero F. (52° C) but it is extremely advisable, when the temperature gets below 0°. C., to draw off the water solution, because, should it freeze, the engine cylinder or the water jacket or both will crack and render outfit absolutely useless.

If for any reason Glycerine and Alcohol cannot be obtained, an excellent substitute is a solution composed of 4.2 lbs. of 75 per cent. Calcium Chloride to each gallon of water.

This solution would be about 31° beaume, or 1.27 specific gravity, which solution has a freezing point of about 55° C. or 23° below zero F.

Calcium Chloride is much easier to obtain than Glycerine and Alcohol, and it has the decided advantage in that it is much easier shipped.

2. Remove the handhole plate from one side of crank case of engine and poor in about one gallon of the engine oil that comes with outfit. When the proper amount of oil is in the crank case, the oil gauge on the left-hand side of engine bed will

show about two-thirds full. When the weather is cold, however, the oil will be too heavy to immediately flow up into the gauge and will not do so until it becomes warm. If you place one gallon in the crank case as above set forth, you need have no apprehension. Replace plate and then fill bearing on Commutator end of Generator with oil also. This bearing is a ring-oiled bearing and once filled will require only intermittent filling unless oil is spilled out when engine is shipped around. The entire engine and bearings, other than the one mentioned, is lubricated by the splash system from the crank case.

3. See that Gasoline tank is filled with gasoline that has been strained. Any foreign matter in gasoline will clog up Carburetor or connections between it and the tank.

4. See that small needle valve on the bottom of Carburetor is open one and one-half turns. The best way to be assured of this is to first close it tight and then open it the required amount.

5. See that small lever on Breaker Box of high tension magneto is about one-half way down for starting and when the engine starts it should be pushed down (advanced) as far as it will go. This lever is the spark control lever and operates exactly the same as that on the steering post of an automobile. It is retarded (up) when starting, and advanced (down) when the engine is running. It is important that this lever be adjusted as set forth above, otherwise the engine will not operate at its proper speed.

6. See that electrical connections between magneto and spark plug and magneto and switchboard

are tight. Loose connections will cause a poor spark and engine will not start.

After the above adjustments have all been made the engine is ready to start and you should proceed as follows:

1. Open small single blade switch on switchboard. This switch, when closed, short circuits the ignition system and stops engine. Therefore, the engine will not start until this switch is opened.

2. Press finger on button switch on circuit breaker on switchboard for a few seconds and the Generator will operate as a motor until the engine starts. After the engine comes up to speed, the Generator will generate current.

Should the engine not start after a few seconds, it may be due to any of the following causes:

1. In very cold weather gasoline, unless warmed, will not vaporize and it is extremely difficult to start an engine under these conditions. When the temperature is low and you experience this difficulty it is advisable to draw off part of the water and heat it. Hot water around the jacket will vaporize the gasoline, and engine will start without further trouble.

2. Spark plug points may be too far apart or too close together. Remove spark plug with wrench supplied with outfit and after cleaning points set them not more than 1-32″ apart, replace plug tightly in cylinder head and connect wire.

3. Cylinder may not be receiving gasoline from carburetor. This may be due to some foreign substance clogging the pipe between the gas tank and carburetor or clogging the small intake valve con-

trolled by lever at bottom of carburetor. To remedy the former, shut off gasoline at valve on gas tank, remove pipe and see that it is clear; also suck on, not blow through pipe connection on carburetor. The chances are very remote that the second fault is present and it can be removed by holding hand over air intake on carburetor. The suction from the cylinder will clear the passage.

4. *Too Much Gasoline.* If the cylinder receives too much gasoline, the mixture will be too "rich" and will not ignite. The gasoline flow is controlled by small valve lever at bottom of carburetor, and this should be open about one or one and a half full turns. The proper amount of opening, however, will vary with temperature and it is right when engine is running with load at its normal speed (about 1,250 revolutions per minute).

5. *Too Little Gasoline.* If too little gas is being fed to cylinder the mixture will be too "thin" and will not ignite. To determine this, place hand over air intake of carburetor. Do not interfere with gasoline intake valve, if engine continues to run normally after starting. In this case, all that was necessary was to get a fairly heavy charge of gas in cylinder for starting. Do not keep air intake closed for more than a dozen or so revolutions of engine or you will flood the cylinder with pure gasoline and it will not ignite.

Seven times out of ten, after engine has once been run and will not start again, there is no gasoline in tank. A gasoline engine will not operate without gasoline. Do not look in gasoline tank with match.

6. *Platinum Points in Magneto Breaker Box May Be Dirty.* To remove cover of breaker box, slide the spring that holds it over to one side. You can then lift off the cover. Clean breaker points with clean rag. Do not scrape them.

When the engine runs smoothly, take a piece of fine sandpaper No. 00 that is shipped with the outfit, and hold it on commutator, while it is revolving, until commutator is thoroughly polished. Do not use emery or emery cloth. It will ruin commutator and break down insulation. Do not be afraid of a shock with this outfit. It cannot generate more than 32 volts and it cannot be felt. You can touch any part, any time, with both hands, without danger.

It is necessary to keep commutator very clean because of the low voltage, and any grease thereon acts as insulation and machine will not generate current. See that brushes make good contact with commutator but do not have tension too tight; just enough tension on springs to hold brushes in place is all that is necessary. Any greater amount will cause the brushes to wear a rut in commutator and impair its efficiency.

With this outfit you have a standard 16 cell, 32 volt, 80 ampere hour Willard Storage Battery and the following instructions and information apply particularly to this type of battery. You should, however, be thoroughly familiar with the practical operation of storage batteries in general and by reading carefully the storage battery data under the heading "General Storage Battery Data" contained in this article, you will then be in a far better position to handle this apparatus.

Charging the Battery

As soon as the proper connections have been made and the engine is running normally and the batteries properly filled with the electrolyte they must be put on charge at half the finish rate stamped on the name plate. If this rate is not stamped on plate it is safe to assume that the finish charge rate is about five or six amperes and with the amount of current showing on the ammeter (no lights burning) the battery should be charged continually until the specific gravity of the electrolyte stops rising. At this point all the cells should be "gassing" freely and the voltage should read at least 2.4 volts per cell. Test voltage with voltmeter supplied with outfit. This voltmeter is a low voltage instrument and no more than one cell at a time should be tested with it. Remember there are 16 cells to the battery and you will get a voltage reading from any one of them by placing one terminal of the voltmeter on the positive terminal of the other cell and the other meter terminal on the negative cell battery.

The amount of current supplied by the generator may be varied at will up to 31.25 amperes by increasing or decreasing the resistance in series with the field of the generator. This is done by turning the black rheostat control wheel on the switchboard. Arrows on this wheel show which way to turn it to increase or decrease current.

If during the charge the temperature of the electrolyte in any one cell exceeds 100° F. the current from the generator must be reduced until the temperature falls below 90° F. This will

necessitate a longer time to complete the charge, but must be strictly adhered to.

When the cells are completely charged the specific gravity of the electrolyte in each cell should be between 1.280 and 1.300. If above this (1.300) remove a little electrolyte with the hydrometer syringe and add a little distilled water while the battery is still charging (in order to thoroughly mix solution) and after three hours, if the electrolyte is within the limits specified, the battery is ready for use. If the specific gravity of the electrolyte is below 1.280 while the voltage of the cells is about 2.4 (after first charge only) remove a little electrolyte and add the same quantity of 1.400 specific gravity electrolyte. Leave on charge as before. You cannot test 1.400 electrolyte with your hydrometer, because the scale does not read that high, but you can mix 1.400 specific gravity electrolyte by taking seven parts, by volume, of pure sulphuric acid and pouring it into nine parts of volume of distilled water. The acid should be poured into the water and allowed to cool below 90° F. before being placed in battery cells.

The standard vent plugs are now inserted and the battery is ready for service.

After this preliminary charging you should experience no difficulty at any time with the battery, inasmuch as it is, when properly connected to the switchboard, "floated" across the generator terminals and when the generator set is being used for incandescent lighting purposes, that is to say, for lighting up the huts, etc., the ammeter should show about one ampere for every 25 watt lamp in

use and about one and one-quarter amperes for each 40 watt lamp in use. In this way a slight amount of additional current will be charged into the battery and it will therefore remain continually charged.

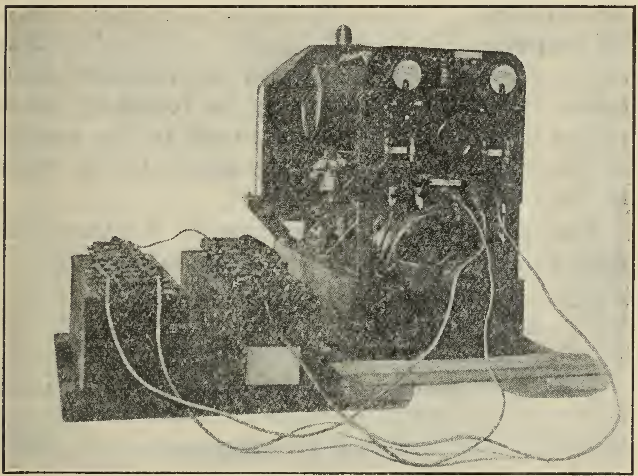


FIG. 324
Switchboard Showing Automatic Cut-out, Starting Switch, Voltmeter, Ammeter, Field Regulator, 25 and 32 Volt-Switches

DISCHARGING AND RECHARGING

The lights may be operated from the storage battery without running the engine, and in this case the rate of discharge will be according to the following table:

Delivering						hours
1 ampere	battery	will	supply	same	for	80
2 amperes	"	"	"	"	"	40
4 amperes	"	"	"	"	"	20
8 amperes	"	"	"	"	"	10
10 amperes	"	"	"	"	"	8
12 amperes	"	"	"	"	"	6¾
20 amperes	"	"	"	"	"	4
30 amperes	"	"	"	"	"	2 2-3

and so forth. The number of amperes being taken from the battery may be found by multiplying the number of lamps in use by the wattage of the lamp and dividing the result by 32, which is the battery voltage.

For example: You are using 8 twenty-five watt lamps and four forty watt lamps.

$8 \times 25 = 200$ watts
$4 \times 40 = 160$ watts

Total 360 watts = lamp consumption in watts

$$\frac{360}{32} = 11\tfrac{1}{4} \text{ amperes.}$$

By referring to the preceding table it will be found that the battery would discharge 12 amperes for 6¾ hours and by using the above formula you can work out the solution for any condition.

It is not advisable to completely discharge battery under any circumstances because heavy discharge rates maintained for any great length of time will injure the battery.

When the lights are operated from the storage battery without the engine running, the battery

should be charged later and specific gravity readings taken of the electrolyte until the hydrometer shows a reading of from 1.280 to 1.300.

The large incandescent lamp supplied for the motion picture machine consumes 30 amperes at 25 volts and is known as the Edison T 29 Monoplane Filament Projection Lamp. When using this lamp the leads from the lamp house must be connected to the 25 volt switch on the switchboard. Under no circumstances connect it to the 32 volt switch or lamp will immediately burn out. This lamp may be operated for a short time, about 2 hours, from the battery, without the engine running. This, however, should only be done in case of emergency and the batteries should be charged as soon as possible afterwards. With the engine running and the moving picture 30 ampere lamp in operation, the ammeter on the switchboard should read 30 amperes. The lamp then is consuming the current supplied by the generator and the storage battery in this case is simply floated across the line, keeping the lamp voltage normal. Do not try to operate lamp from generator without storage battery connected to switchboard.

In cases of great emergency, where it is impossible to take the engine, the batteries may be used alone to run the picture machine and lamps for a short period. Care should be taken to connect the moving picture lamp wires to the twelfth cell terminal of battery and the lamps used for lighting purposes to the 32 volt terminal at the sixteenth or last cell.

As before stated, the battery alone, under no

circumstances, should be used in connection with the motion picture lamp for a longer period than 2 hours because the battery will become overdischarged. The amount of current still in battery can be determined by testing the electrolyte with the hydrometer and it should not be allowed to drop below 1175, after which it should be charged from the generator at from 10 to 15 amperes until the specific gravity of the electrolyte reaches about 1265 and then the amperes should be reduced to about 5 and the charge continued until the electrolyte reading is between 1275 and 1300.

Regulating Engine to Procure Proper Amperage. The amount of current delivered by the generator is in direct proportion to the amount flowing through the shunt field of the machine. It may be varied up to 31¼ amperes by adjusting the rheostat control wheel on the front of the switchboard. The generator will not deliver its full capacity unless the engine is running at its normal speed of 1250 revolutions per minute. Should the engine be running too slow with generator delivering current the carburetor on the engine may be delivering too much or too little gasoline and this, as previously stated, may be adjusted by means of the small needle valve lever on the bottom of the carburetor.

Care of the Battery

In the proper care of a storage battery if the following things are remembered you will escape 75 per cent of your battery troubles:

First—Test the specific gravity of all cells with a hydrometer two or three times a month. If any

of the cells are below 1200, the battery is more than half discharged, and it should be charged with the ammeter on the switchboard reading 10 amperes, until the normal specific gravity is reached (1275 to 1300).

Second—Pure water must be added to all cells regularly and at sufficiently frequent intervals to keep the solution at the proper height. Add water until solution is one-half inch above top of plates.

Never let solution get below top of plates.

Plugs must be removed to add water, then replaced and screwed on after filling.

The battery should be inspected and filled with water once every week in warm weather and once every two weeks in cold weather.

Do not use Acid or Electrolyte, only pure water.

Do not use any water known to contain even small quantities of salts or iron of any kind.

Distilled water or fresh, clean rain water only should be used.

Use only a clean vessel for handling or storing water.

Add water regularly, although the battery may seem to work all right without it.

In order to avoid freezing of the battery, it should always be kept in a fully charged condition. A fully charged battery will not freeze in temperatures ordinarily met.

Electrolyte will freeze as follows:

Sp. gr. 1,150, battery empty, 20 above zero F.
Sp. gr. 1,180, battery ¾ discharged, zero F.
Sp. gr. 1,215, battery ½ discharged, 20 below zero F.

Sp. gr. 1,250, battery ¼ discharged, 60 below zero F.

Therefore, it will be seen that there is no danger of the battery freezing up if it is kept at a specific gravity of from 1250 to 1300 and it should be kept as near 1275 as possible. Under no circumstances should acid or electrolyte be added to the cells to bring them up to the required specific gravity. Nothing but pure water must be put in the cells after the battery has been once placed in commission and the specific gravity must be kept up by charging only.

General Storage Battery Data

A storage battery, secondary battery, or accumulator, as it is variously called, is an electrical device in which chemical action is first caused by the passage of electric current, after which the device is capable of giving off electric current by means of secondary reversed chemical action. Any voltaic couple that is reversible in its action is a storage battery. The process of storing electric energy by the passage of current from an external source, is called charging the battery; when the battery is giving off current, it is said to be discharging. A storage battery cell has two elements or plates, and an electrolyte. The two plates are usually made of the same material, though they may be of two different materials. The material used in the construction of both plates of battery furnished is lead.

Polarity.—The terms positive and negative are employed to designate the direction of the flow of current to or from the battery; that is, the posi-

tive plate is the one from which the current flows on discharge, and the negative plate is the one into which current flows on discharge. In a lead battery the positive plate, on which the lead peroxide is formed, has a comparatively hard surface of a reddish-brown or chocolate color, while the negative plate, which carries the sponge lead, has a much softer surface of a grayish color.

Electrolyte.—The electrolyte used with the lead type of battery is always a diluted solution of sulphuric acid. The specific gravity of the electrolyte, when the battery is fully charged, varies from about 1.210 for stationary batteries to 1.300 for automobile ignition batteries and other portable batteries.

The proper specific gravity to use varies with the conditions, and the specific gravity may be found by the use of a hydrometer. When the cells of the battery shipped with this outfit are fully charged, the specific gravity of the electrolyte, as indicated by the hydrometer, should be 1275 to 1300 at 70 degrees F. The final density is the usual practice. None but sulphur or brimstone acid should be used. When diluting, the acid must be poured into the water slowly and with great caution.

Never Pour the Water into the Acid.—The specific gravity of commercial sulphuric acid is 1.835, and 1 part of such acid should be mixed with 5 parts (by volume), of pure water. Care should be taken that no impurities enter the mixture. The vessel used for the mixing must be a lead-lined tank or one of wood that has never contained any other acid; a wooden washtub or

spirits barrel answers very well. The electrolyte when placed in the cell should come ½ inch above the top of the plates. Before putting the electrolyte in the cells, the positive pole of each cell should be connected to the negative pole of the next cell in the series and the whole battery of cells should be connected, through a main switch, to the charging source—the positive pole of the battery to the positive side of the charging source, and the negative pole to the negative side. After adding the electrolyte the battery should be charged at once or at least inside of 2 hours. A little pure water should be added occasionally to the electrolyte to make up for evaporation, and a small quantity of acid should be added about once a year to make up for that thrown off in the form of spray or that absorbed by the sediment in the cells. Do not use anything but pure distilled water in storage batteries because any impurities such as those commonly found in tap or well water will in a very short time absolutely ruin the battery.

Test of Specific Gravity—The specific gravity of the electrolyte is the most accurate guide as to the state of charge of a lead-type storage battery. The test of the specific gravity is made by means of a hydrometer having a suitable scale for the type of cell to be tested. In all portable types of batteries, and ordinarily in vehicle batteries, it is usually necessary to draw some of the electrolyte from the cell in order to test its specific gravity with the hydrometer, which should have a scale reading from 1150 to 1300.

Charging—The normal charging rate is the same as the 8-hour discharge rate specified by

manufacturers. The charge should be continued uninterruptedly until complete; but if repeatedly carried beyond the full-charge point, unnecessary waste of energy, a waste of acid through spraying, a rapid accumulation of sediment, and a shortened life of the plates will result. At the end of the first charge, it is advisable to discharge the battery about one-half, and then immediately recharge it. It is advisable to overcharge the batteries slightly about once a week, in order that the prolonged gassing may thoroughly stir up the electrolyte and also to correct inequalities in the voltages of the cells. If the discharge rate is very low, or if the battery is seldom used, it should be given a freshening charge weekly.

Indications of a Complete Charge—A complete charge should be from 12 to 15% greater in ampere-hours than the preceding discharge. The principal indications of a complete charge are: (1) The voltage reaches a maximum value of 2.4 to 2.7 per cell, and the specific gravity of the electrolyte a maximum of 1275 to 1300 per cell. If all the cells are in good condition and the charging current is constant, maximum voltage and specific gravity are reached when there is no further increase for ¼ to ½ hour. (2) The amount of gas given off at the plates increases and the electrolyte assumes a milky appearance, or is said to boil.

Voltage Required—The voltage at the end of a charge depends on the age of the plates, the temperature of the electrolyte, and the rate of charging; at normal rate of charge and at normal temperature, the voltage at the end of the charge of a newly installed battery will be 2.5 volts per cell

or higher; as the age of the battery increases, the point at which it will be fully charged is gradually lowered and may drop as low as 2.4 volts. All voltage readings are taken with the current flowing; readings taken with the battery on open circuit are of little value and are frequently misleading. After the completion of a charge and when the current is off, the voltage per cell will drop rapidly to 2.05 volts and remain there for some time while the battery is on open circuit. When the discharge is started, there will be a further drop to 2 volts, or slightly less, after which the de-

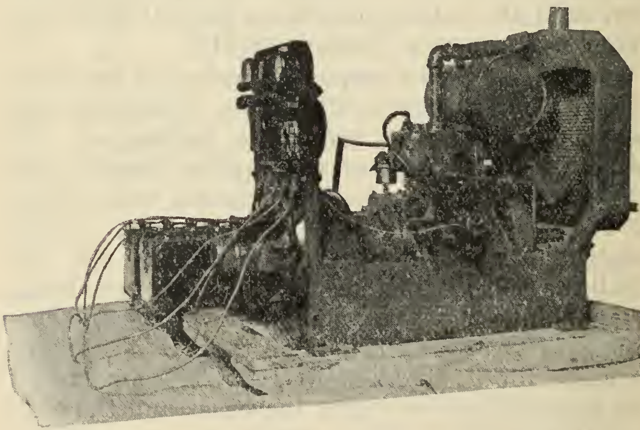


Fig. 325
Side View Showing Bosch Magneto

crease will be slow. Cells should never be charged at the maximum rate except in cases of emergency.

Direction of Current—The charging current must always flow through the battery from the

positive pole to the negative pole. If it is necessary to test the polarity of the line wires when no instruments are available, attach two wires to the mains, connect some resistance in series to limit the current, and dip the free ends of the wires into a glass of acidulated water, keeping the ends about 1 inch apart. Bubbles are given off most freely from the negative end.

Discharging—Heavy overdischarge rates maintained for a considerable time are almost sure to injure the cells. The normal discharge rate should not be exceeded except in case of emergency. The amount of charge remaining available at any time can be determined from voltage and specific-gravity readings. During the greater part of a complete discharge, the drop in voltage is slight and very gradual; but near the end the falling off becomes much more marked. Under no circumstances should a battery ever be discharged below 1.7 volts per cell, and in ordinary service it is advisable to stop the discharge at 1.75 or 1.8 volts. If a reserve is to be kept in the battery for use in case of emergency, the discharge must be stopped at a correspondingly higher voltage. The fall in density of the electrolyte is in direct proportion to the ampere-hours taken out, and is therefore a reliable guide as to the amount of discharge.

MISCELLANEOUS POINTS

Restoring Weakened Cells—There are several methods of restoring cells that have become low: (1) Overcharge the whole battery until the low cells are brought up to the proper point, being

careful not to damage other cells in the battery. (2) Cut the low cells out of circuit during one or two discharges and in again during charge. (3) Give the defective cells an individual charge. Before putting a cell that has been defective into service again, care should be taken to see that all the signs of a full charge are present.

Sediment in Cells—During service, small particles drop from the plates and accumulate on the bottom of the cells. This sediment should be carefully watched, especially under the middle plates where it accumulates most rapidly, and should never be allowed to touch the bottom of the plates and thus short-circuit them. If there is any free space at the end of cells, the sediment can be raked from under the plates and then scooped up with a wooden ladle or other non-metallic device. If this method is impracticable, the electrolyte, after the battery has been fully charged, should be drawn off into clean containing vessels; the cells should then be thoroughly washed with water until all the sediment is removed, and the electrolyte should be replaced at once before the plates have had a chance to become dry. In addition to the electrolyte withdrawn, new electrolyte must be added to fill the space left by the removal of the sediment; the new electrolyte should be of 1.3 or 1.4 sp. gr. in order to counteract the effect of the water absorbed by the plates while being washed. If at any time any impurities, especially any metal other than lead or any acid other than sulphuric acid gets into a cell, the electrolyte should be emptied at once and the cells

thoroughly washed and filled with pure electrolyte.

Idle Batteries—If a battery is to be idle for, say, 6 months or more, it is usually best to withdraw the electrolyte, as follows: After giving a complete charge, siphon or pump the electrolyte into convenient receptacles, preferably carboys that have previously been cleaned and have never been used for any other kind of acid. As each cell is emptied, immediately refill it with water; when all the cells are filled, begin discharging and continue until the voltage falls to or below 1 volt per cell at normal load, and then draw off the water.

Putting Battery into Commission—To put an idle battery into commission, first make sure that the connections are right for charging; then remove the water, put in the electrolyte, and begin charging at once at the normal rate. From 25 to 30 hours' continuous charging will be required to give a complete charge.

This does not apply to battery received with this outfit because it has been fully charged before leaving the factory and still holds this charge because the electrolyte was drawn off after a complete charge and the cells hermetically sealed with the red rubber caps. After you commence charging, as set forth in a previous paragraph, it will take only a fraction of the time set forth in the above paragraph to bring the battery up to its full capacity.

Sulphating—Lead sulphate is practically an insulator. Some of this material is formed in all lead-sulphuric-acid storage cells on discharge and is reconverted to lead oxide or lead peroxide on

recharging the cell. If present in excessive quantities, the sulphate adheres to the plates, especially the positive, in white soluble patches, preventing chemical action, increasing the resistance of the cell, and causing unequal mechanical stresses that may buckle the plates. The most frequent causes of sulphating are overdischarging, too high specific gravity of electrolyte, and allowing the battery to stand for a considerable length of time in a discharged condition.

THEORY OF THE ENGINE

In order to be able to understand the machine, it will be necessary for you to have a rudimentary knowledge of what goes on inside the engine.

To begin: In order to have power we must use some heat agent—in this instance gasoline. Our 1 K. W. plant as usually operated consumes one pint of gasoline per hour and burns about 460 cubic feet of air mixed with the gasoline. The mixing of gasoline and air is done in the carbureter and we will hereafter call the mixture of air and gasoline, Gas. This gas is explosive and can be ignited by an electric spark and with compression and proper ignition will give power and turn the shaft as follows:

Referring to (Fig. 331, Plate H), we see the gas coming from the carbureter (G) through the valve (I), called the inlet valve, into the cylinder. The piston (P) is moving downward as shown by the arrow, it being at this time pulled downward by the connecting rod (R) which is pulled downward by the crank (A) on the shaft (S) which is (we will say) being revolved by the generator at

first. The movement of the piston downward creates a partial vacuum and at the same time the inlet valve opens and gas rushes through the carbureter and through the intake pipe (H) and from there past the valve (I) into the cylinder to fill this partial vacuum. The intake valve opens at the beginning of the stroke, or nearly that, ac-

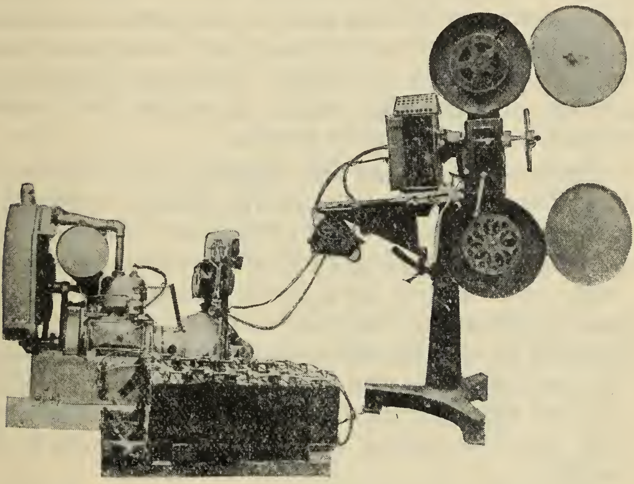


FIG. 326

cording to the ideas of the designing engineer. At the bottom of the stroke the intake valve will close, and we then have a volume of gas, retained in the combustion chamber and space in the cylinder, through which the piston has passed.

As the crank continues to revolve (we refer to Fig. 332, in which you see both valves closed), the advancing piston is decreasing the size of the space containing the gas, hence putting same

under compression, which in this engine ranges between 40 and 50 pounds per square inch. At the moment the piston arrives at the top of the stroke, or dead center (being when the crank A) and the connecting rod (R) are in line), the charge of gasoline vapor and air is exploded by means of an electric spark, generally given with a spark plug (U) described later. Upon firing, the expansion of the gas is very great, causing a pressure of 200 to 300 pounds to the square inch and thus forcing the piston downward again, as shown in Fig. 333, which is called the power stroke, or the explosion stroke.

We now have had the intake stroke, the compression stroke, and the power stroke. After the power stroke has arrived at the limit of downward movement, we may get rid of the burned gases in order to be ready for a fresh charge, and that is accomplished by the mechanical opening of the exhaust valve (E) the moment the piston is about to start upward, and the piston then pushes the gas out through this valve and through the pipe (M) into the muffler, or into the air if there is no muffler.

We have described the four cycles, each cycle being represented, as we have seen, by intake, compression, power and exhaust strokes respectively.

THE SPARK PLUG

A spark plug is a device so constructed as to make an electrical gap across which the electric spark jumps and is to be exposed to the gases in the cylinder, firing them as a consequence.

There are many kinds of spark plugs, the most universal probably being the same as used on this engine, there being an electrode, or wire, running down through the center of a porcelain core, this being surrounded by metal threaded parts which screw into the cylinder, and from which the central electrode is insulated by the porcelain. The end of the central electrode is brought to within a short distance of the extension of the outer metal shell on the exposed part of the spark plug inside the cylinder. One wire from the magneto is connected to this central electrode on top of the spark plug by means of the thumb nut thereon. The ground is through the base of the magneto to the engine, thereby completing the circuit, when the spark plug jumps across the gap between the point of the electrode and the extension of the metal case of the spark plug.

For magneto service these extremities should be adjusted to about 1-50 inch gap. If they are too wide apart there will be trouble in missing.

Be sure all wire connections are tight.

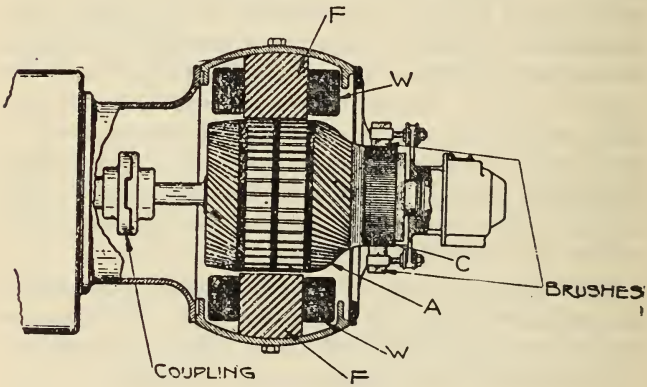
MAGNETO AND SPARK PLUG TEST

If at any time you wish to determine whether the magneto is firing properly, simply disconnect the wire at the spark plug, and holding the wire 1-8 inch from engine at any point, and see if the spark jumps across the engine in motoring or running.

To try the spark plug for firing, remove the plug from the cylinder head with special wrench provided, then reattach wire to the plug and lay the plug on the engine.

COMPRESSION TEST

Try compression by turning the flywheel over to bring the piston up on the compression stroke. If this turns over without resistance, your engine has for some reason "lost its compression." As there are only four openings into your compression chamber you can quickly try these out



GENERATOR

FIG. 327

individually. First, the spark plug hole. A little oil poured around the plug will show bubbles when you bring the piston up for compression if there is any leakage at this point. Most probably the leaking is through either the intake or exhaust valves. Unscrew the nuts on top of the cylinder head and take off complete cylinder head and valves for examination. On both of these valves you will find slots on top in which you can use a screwdriver for turning the valves back and forth

to work any deposit or carbon or foreign matter that may be preventing them from making a tight seat. If dirty, clean thoroughly with gasoline. With these tight, and still no compression, it must be a leakage past the piston. This is practically impossible in this engine, unless you have run it "dry" and stuck or broken the piston rings.

IN GENERAL

In general, the best advice is to leave all parts of the engine alone until you have carefully thought out where the trouble probably lies and what is causing it, and this can be clearly and accurately done by the most inexperienced man if he will only bear in mind and trace out the three lines, compression, ignition and mixture.

The generator is shunt wound which is the simplest form of generator used. Fig. 327 gives cross section of same. "A" is armature which revolves

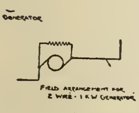


FIG. 328

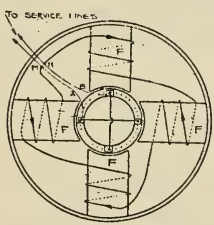


FIG. 329

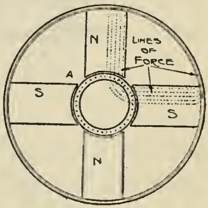


FIG. 330

in fields "F" and shaft of armature being fastened to engine shaft as shown by coupling is turned at engine speed. The field windings "W" energizes the fields and consists of many turns of fine wire. The armature windings as they pass through the

PLATE H

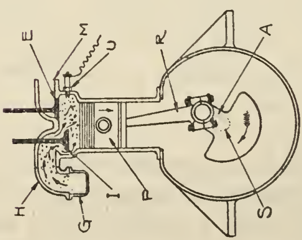


FIG. 331
SUCTION

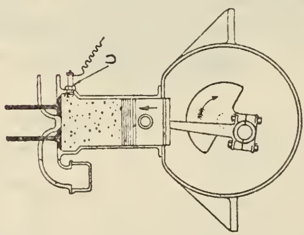


FIG. 332
COMPRESSION

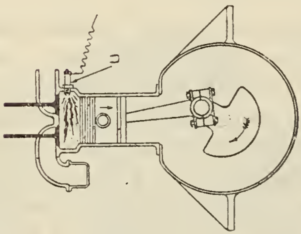


FIG. 333
EXPLOSION

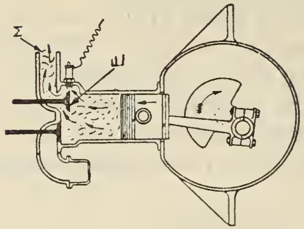


FIG. 334
EXHAUST

CYCLE OF OPERATIONS
IN A
FOUR STROKE CYCLE
GAS ENGINE

lines of force produced by fields generate electrical power which is collected from the commutator "C" and delivered to the battery and service lines as required.

There is only one bearing on generator which is as shown, the split coupling connecting armature shaft to engine shaft constituting the other bearings.

By referring to Fig. 328 the wiring diagram will be seen for a shunt wound generator. Fig. 329 shows the same as it is actually arranged on the generator. The fields "H" are wound around the pole pieces and the two wires leading to them join the armature leads (A) and (B) at (M) and (N) or as the name implies, the shunt wound generator means that the field windings are shunted or paralleled with the armature leads.

Fig. 330 shows the armature and fields and as noted the field poles alternate North pole and South pole magnetism. This could be compared to + and (—), the North pole comparing to + and South pole to (—), because the lines of force flow from (N) to (S) as current always flows from + to (—).

Referring again to Fig. 330 the lines of force produced by the fields flow from the (N) poles through the iron body of the armature to the South poles and return to the (N) poles through the outside frame of the generator.

As the windings of armature as represented pass through the lines of force, electric current is generated which is collected and delivered by the commutator to the service lines or battery.

THE HIGH POWER ARC IN MOTION PICTURES

High power arcs may be classified broadly as electric arcs, having positive craters with intrinsic brilliancies greater than can be obtained with pure carbon positive craters. Before explaining in detail the method of operation of a high power arc, it is necessary for us to appreciate the limitations of the pure carbon arc. Practically all of the light from a pure carbon arc emanates from the incandescent positive crater. Incandescence is a function of temperature and, therefore, in order to obtain a light source of maximum brightness, a substance must be used which can be maintained at the highest possible temperature. As is well known, carbon has the highest melting point of all substances, and for this reason it has been used in all cases where light sources of greatest brilliancy have been desired. In an electric arc between pure carbon electrodes, the surface of the tip of the positive electrode is maintained at a temperature of over 3,700 degrees Centrigrade. The carbon surface, when heated to this point, gives forth about 160 candle-power for every square millimeter of its surface. This brilliancy we may call the maximum obtainable from any solid by temperature radiation. When such a carbon arc is forced by, let us say, doubling the current, the brilliancy of the crater is not increased proportionately as might be expected. Instead the carbon is consumed at a faster rate without any material increase in the temperature

of the crater. It is, therefore, perfectly useless to force a carbon arc beyond a certain point where the crater is practically at the volatiling point of carbon and has, therefore, reached its maximum theoretical efficiency.

In searchlight work, the only practical way of increasing efficiency was to increase the intrinsic brilliancy of the source of light. Since this was impossible by using solids, an investigation was made of vapors and gases. There is no known limitation to the temperature to which vapors may be heated, but on the other hand, vapors and gases do not obey any known laws of radiation such as apply to incandescent solids. In general gases and vapors are very poor brightness producers when compared with incandescent solids. For instance, the arc flame in a pure carbon arc consists of vapor at a temperature greater even than the temperature of the positive crater and yet it gives a brilliancy of only about one candle power per square millimeter, as compared to the 160 c.p. per sq. mm. given by the incandescent crater. Luminescent or light-giving vapors have long been used as light sources of exceptional efficiency, but they had never even been considered as competitors with incandescent solids when intrinsic brilliancy was required. The mercury vapor arc, the yellow and white flame arcs and the magnetic arc are all among the most efficient of light sources, but their intrinsic brilliancies are very low, all of them being less than 5 c.p. per sq. mm. In the high power arc, vapor has been made use of for the first time as a light producer of excessive brilliancy. The special vapor-producing materials are placed entirely in

the core of the positive carbon. This carbon is so constructed that when burned at the proper current, it forms a deep crater. It is usually rotated to keep this crater uniform. The special flame material enters the arc entirely from the bottom of this deep crater where the impregnated core is exposed to the arc. The negative carbon is so arranged that the negative flame sweeps across the positive crater in such a manner that the light-giving vapor from the positive core is confined and compressed in the crater. By properly confining this vapor in the crater by means of the negative flame, the brilliancy of the vapor is very greatly increased, and instead of obtaining brilliancies in the neighborhood of 5 c.p. per sq. mm., we obtain brilliancies ranging from 500 to 900 c.p. per sq. mm. These are figures which were hitherto unknown on earth. The sun at high noon is the only other source which man has seen that can approach such a brilliancy. The noon day sun has an intrinsic brilliancy of about 920 c.p. per sq. mm. Figure 335 shows graphically how this new type of arc compares in brilliancy with all of the brightest illuminants known. It is evident that by utilizing concentrated and compressed vapor of special materials at temperature of the electric arc, a new form of illuminant has been introduced with many new and very interesting characteristics. It was the remarkably high intrinsic brilliancy of this new arc which gave it its value in searchlight work, but in the application of this arc to other uses other equally important properties of this light have been controlled and accentuated so that the light is also proving revolutionary in other fields.

The motion picture industry is without doubt the greatest light-using industry in the country and the demand of this industry for more light has been continuous and insistent with the advance of the art. There are two main departments of lighting in the motion picture industry; the producers' lighting, which consists in lighting the studios for photographing the pictures, and the exhibitors' lighting, which consists of the light for projecting the pictures on the screen. These two fields are very different and each has required a special development and adaptation of the high power arc.

The arc was most readily adapted to studio lighting. In this field the high intensity arc, better known as the Sunlight Arc, met with the immediate favor of producers and camera men, who found that its unique qualities opened up entirely new fields of photography. The use of a single lighting unit having an intensity of over 100,000 c.p. made it possible to invade with the motion picture camera places which were hitherto inaccessible. The largest ball rooms and theatre interiors in the country have been illuminated sufficiently to take excellent motion pictures with from two to four of these powerful units. This one use in itself is a tremendous saving in expense to the producer who is enabled for the first time to go out of the studio to any desired interior location with the same freedom that he has been used to in going out on exterior locations. This single use has made the light indispensable to producers.

In the studio sunlight arcs are of great value in illuminating the large sets. When placed at a

height of about 20 feet above a set, the amount of actinic light on the set is sufficient to give good photographic results more than 60 feet from the unit without the use of lenses or mirrors. The open arc used in this manner as a flood-light has been found valuable in high-lighting a large set and giving a predominant direction to the main lighting, thus avoiding the disagreeable cross shadows which are so noticeable when several smaller units are used in place of one large unit.

Another use of the open flood light is the illumination of backdrops or scenery outside of windows or doors in interior sets. It is universal practice in taking artistic interiors to have windows, doors or arch-ways through which can be seen daylight or sunlight. To properly produce this effect, a great intensity of light outside of these openings is essential, since the interior is already illuminated to a high level and the exterior must be enough brighter than the interior to give the impression of looking out into daylight. Frequently, sunlight as well as daylight, is required to enter through the opening. It is then necessary to direct the open flood light so that it falls through the opening and makes a patch of light on the wall or floor. Excellent results are obtained with the direct arc for these sunlight effects, and since the source of light, which measures only 5/8″ in diameter, is so small for its intensity that sharper shadows can be obtained with it than can be obtained with any other source in the studio.

In exterior night work the open flood is invaluable to light any large scene. In street night scenes the lights are located at positions and

heights which make the scene appear as though lighted by regular street lamps. Two or three of the arcs as open flood lights will illuminate a section of a street large enough for several hundred actors to take part in such scenes as raids, riots, etc.

Aside from the advantages of intensity and concentration of the high intensity arc in photographic work, several other properties of this arc are worthy of mention. In the first place the confining of the bright vapor in the intensely hot crater makes the light very steady and free from flicker. Small disturbances do not affect the light or change its intensity in the manner that is so noticeable in the small flaming arcs where the light emanates from the arc flame between the electrodes instead of from a deep crater. Another reason for the extreme steadiness of the light is the fact that the high current used (150 Amperes) makes an arc which has considerable inherent stability due to what might be called its own inertia. The advantages of a steady light of high candle power are universally appreciated by Motion Picture photographers.

Another feature which is partly responsible for the unusual efficiency of this unit is that nearly 80% of the total amount of light from the arc falls in the hemisphere toward which the positive carbon is facing. This useful distribution of the light is due to the fact that it is emitted from the crater, hence when the arc is viewed from some point where the crater face is not visible the candle power is extremely low. The Sunlight Arc is the first illuminant for general studio lighting which has taken advantage of this restricted dis-

tribution of light within the zone to be illuminated. Other sources of light all have a uniform light distribution in all directions, and hence must use some form of reflector in order to reflect the 50% of the light which falls away from the scene, back onto the scene. Such arrangements are not only inefficient, but are compromises since half of the light is direct and the other half is indirect and diffused. The high intensity arc on the other hand is capable of producing either all direct or all diffused light as desired, depending on whether the crater is pointed directly toward the scene or toward some diffusing medium or reflector.

We have spoken of the quantity of light from this arc, another and equally important aspect is the quality of the light. Photographers agree that the ideal light for photography is sunlight and north sky-light. The ideal artificial illuminant for photography is that one which most nearly approaches daylight in quality. Daylight is not highly colored, it is usually referred to as pure white, but in comparison with most artificial lights it would be called slightly bluish in hue. The high intensity arc is very similar in quality of light to bright daylight, that is, the combination of sunlight and skylight, it is clean bluish white in color. The arc, however, although nearly identical with daylight in the visible spectrum has the advantage over daylight in the ultra-violet or actinic portion of the spectrum. The light from the sun loses from 50 to 75 per cent of its actinic value in penetrating through the 100 miles of the earth's atmosphere. The high intensity arc, however, loses none of its actinic value on

the scene since it has no appreciable amount of atmosphere to penetrate. It has been found that for the same amount of illumination on a subject, the High Intensity Arc is more actinic than daylight. The quality of the light has made it indispensable in the newer branches of motion picture photography. The uniform brilliancy throughout the entire spectrum gives the ideal light for motion pictures in natural colors. The actinic value of the light has made it possible to take excellent interior photographs with the ultra speed camera, taking pictures at the rate of 160 per second.

Some of the uses of the open arc without the accessories have been already described. The following outline of uses with the accessories will give an idea of the flexibility which can be obtained with a unit having one very concentrated and intense source of light.

When it is desired to limit the angle through which the open flood light spreads, the Iris shutter is used. By closing down the shutter the lighted area is decreased in size but the intensity remains the same. When the Iris shutter is nearly closed the flood light then appears as a spot light since the light has a spread of only a few degrees. This is, in reality, a spot light without a lens. It can be used for special effects. This spot light also has an advantage not obtainable in any lens spot light, that is, it can be spread from an angle of a few degrees up to an angle of over 150 degrees without decreasing the illumination. In lens spotlights the illumination decreases as the square of the increase in angle of spread.

Another arrangement of the Studio Outfit is with the diffusing front door. The purpose of this accessory is to make possible a softer light than that obtained by the direct arc.

The open arc casts very sharp edged shadows which are much desired when simulating sunlight or in special silhouette effects, but many uses demand softer shadows, especially in illuminating interior scenes. The diffusing door not only spreads the light very evenly in all directions, but it acts as though the source of light were now two feet in diameter instead of 5/8″ diameter as it is with the open arc. Shadows cast by this arrangement are, therefore, more blended and softer.

The most usual use of this arrangement is to intensify the diffused light from a certain direction on a medium or small sized scene. It is used to best effect with other units such as banks of mercury vapor arcs. The banks supplying the general illumination from several directions and the diffused studio arrangement intensifying this from one direction causing a more artistic effect by accentuating lights and shadows.

When the Iris Shutter is used with the diffusing door the effect is different than in the case of the open arc. Instead of changing the angle of spread, it changes the intensity of the light without affecting its distribution. Hence closing down the Iris with the diffusing door causes the light on the whole scene to fade away from full intensity to darkness. This arrangement gives the camera man a unit where he can adjust the strength of his light on the scene between wide limits and may cause the light to fade away or

increase perfectly uniformly while taking pictures.

The parabolic silvered glass mirror is furnished with the studio outfit for special effect work and long range work. With the arc facing the mirror a beam is produced which measures in the millions of candle power. It is entirely too powerful to be used at short ranges except for special work. One successful short range use of this beam is in the production of an actual visible beam such as a moonbeam or sunbeam entering a window and falling across a room. It is possible to actually register the path of the beam on the motion picture film due to the reflection of light by the dust particles in the room.

The parabolic mirror is also used on large scenes when in addition to the general illumination a spot light is needed on some special part of the scene, such as the dancers in a cabaret scene or any theatrical effect in a large set. In exterior sets this beam has been used with great success in night effects such as lightning, searchlight effects, etc. Good motion picture photography has been taken at night on exterior location with the lighting unit over one quarter of a mile from the camera and the scene.

The extreme flexibility of the high intensity arc unit with its accessories has given the directors and camera men a new tool. New applications and new effects are being produced regularly as the possibilities of this source of light with its reflectors and diffusers are becoming better understood by those who are using it.

Adapting the high power light to motion pic-

ture projection has presented many difficulties and it has only recently been satisfactorily accomplished. It must be realized that up to the present time nothing but incandescent solids have ever been used for sources of light in motion picture projection, whereas in the studio lighting vapor sources, for instance, mercury vapor arcs and flame arcs have been in general use since the first days of motion pictures. The high power arc for projection had to be so steady and free from flicker and all disturbances that it would give as constant and steady a light as the incandescent sources in general use. This has necessitated the development of new carbons and the design of a special mechanism for burning these carbons for projection purposes. The positive carbon is horizontal and lies in the optical axis of the condenser lenses. The negative carbon is positioned at a steep angle to the positive carbon so as not to interfere with or cast any shadow on the optical system. Arcs with the carbons in these positions have been commonly referred to as "right angle arcs." Right angle arcs have not met with favor in the past and have not been used in any of the large motion picture houses. The causes for the failure of the right angle arc have been numerous. All previous right angle arcs have had carbon electrodes and such arcs have a strong tendency to hiss and to become uncontrollable at currents greater than 40 amperes. Moreover, such arcs have been very sensitive to charges in position of the electrodes and means of controlling the carbon feed had never been developed to a point of accuracy necessary in a right angle arc. Furthermore, if the positive carbon contains a

soft core, as is general practice, this core in burning exposes a dark spot at the center of the positive crater, which in turn causes a lack of light on the center of the aperture plate and film. It is quite generally admitted that from the point of view of optical efficiency, the right angled arc is the best, since with this arrangement, the condenser lenses gather the maximum possible light flux.

In this new automatic lamp a special cored carbon is used as the positive electrode. This carbon forms a deep crater which is kept filled with the luminescent vapor, several times the brightness of the surrounding shell, so, therefore, instead of having the center of the crater a comparatively dark spot, it is, on the other hand, the brightest part of the crater. In order to keep this form of arc burning in a perfectly steady manner, the positive crater has to be held within 1/32 of the same position at all times, and the electrode is slowly rotated in this position to keep the crater burning evenly. A novel method of controlling the position of the positive crater has been developed in connection with these arcs. It is an electrical method which takes advantage of the ionized condition of the arc flame and the air immediately surrounding it. A piece of copper insulated from both positive and negative is positioned with its end just at the point over the positive electrode where it is desired to hold the crater. This copper third electrode is connected through a small magnet to one side of the main circuit. When the arc is burning, the arc flame sweeps up past the end of this third electrode. As the crater burns back to this electrode, the arc flame

approaches nearer and nearer to the third electrode until the electrode is in a region of ionized air sufficient to carry enough current from the arc through the third electrode and the magnet to cause the operation of the magnet armature which in turn feeds the positive carbon. As the positive carbon is fed forward, the arc flame is also carried away from the third electrode and the current through the third electrode immediately ceases to flow. This form of control has been developed to a point of complete reliability and an accuracy of crater position better than 1/32 of an inch. The advantage of this in the projector lamp is very evident since the crater is held positively in all three directions; up and down and laterally, it is fixed by the electrode holder which is in line with the optical axis. In the direction of the optical axis it is held accurately at one point (the desired focal point) by means of the third electrode. The negative carbon is fed by means of a coil in series with the arc. This series coil feeds the negative carbon either forward or backward by means of pawls and ratchets, maintaining a constant current at all times. This current control also automatically strikes the arc by feeding the negative carbon up into contact with the positive when the switch is closed and then drawing back until the arc length is such that the current is the desired amount. Two carbon trims have been developed and standardized, one for fifty amperes and the other for seventy amperes.

These lamps have been tried out within the last six months in many of the largest motion picture houses around New York City and the results have been not only surprising but very con-

sistent under all conditions. One theatre having a screen 24 x 20 feet and 170′ throw, was obtaining exactly 2-foot candles on the screen by means of the regular 70 ampere carbon arc. Sperry Lamp on the same projector obtained 6.2 foot candles on the screen or three times the screen illumination with exactly the same current. At another theatre, having a screen 21 x 17 ft. with a 200 ft. throw, we found that they were obtaining 4.1 foot candles with a 120-ampere carbon arc. Installing the high-power lamp on the same projector, 7.5 foot candles were obtained at 70 amperes. This is almost equivalent to doubling the screen illumination with a saving of 40% in current. At the Capitol Theatre, with a screen 18 x 15 ft. and a 212 foot throw a screen illumination of 5.5 foot candles was being obtained from a 125-ampere arc. The Sperry lamp on the same projector gave 8.8 foot candles at 75 amperes, which result is very consistent with the foregoing results at the other theatres.

The following table summarizes these results. The last column in this table which is headed lumens per ampere reduces all of the figures to a common basis for comparison. This figure is obtained by multiplying the foot candles on the screen by the number of square feet in the screen, giving the lumens, and dividing the total lumens by the current in amperes. The resulting figure is a direct measure of efficiency of the complete optical system, irrespective of length of throw and size of screen.

	Direct Current, Amperes	Size of Screen	Area of Screen, Square Feet	Illumination Foot Candles on Screen	Lumens on Screen	Lumens per Ampere
Carbon Arc, A.....	70	24x20	480	2.0	960	13.7
High Intensity, Arc	70	24x20	480	6.2	2976	42.5
Carbon Arc, B.....	120	21x17	357	4.1	1464	12.2
High Intensity, Arc	70	21x17	357	7.5	2677	38.2
Carbon Arc, C.....	125	18x15	270	5.5	1485	12.0
High Intensity, Arc	75	18x15	270	8.8	2376	32.0

It will be readily seen that the well standardized optical arrangements as now used in all large theatres give a limiting efficiency with the carbon arc of about 12 to 14 lumens per ampere. The only method of increasing this efficiency with the standard optical system is by means of a brighter and more efficient source than the carbon arc and this has been accomplished in a striking way by means of the new high-power arc which is giving consistently about three times the lumens per ampere on the screen. With this light increase available to exhibitors, there should be many advancements and improvements in large house projection. It will be possible to use wide-angled screens in the larger sizes instead of being compelled by the lack of available light to use the narrow-angled metallized surface screens. Also it is possible by means of this new lamp to project satisfactory pictures on screens larger than has heretofore been practical. This may increase the size and depth of the future large motion picture houses, if an increased seating capacity is still desired. It will certainly make the outdoor moving picture in amusement and public parks much more popular, since in this field the smallness of

the screen and the lack of sufficient illumination had been the greatest drawback.

But the most urgent need for more light on the screen at the present time is caused mainly by the increasing density of the films which are now being released by all of the largest producers. In addition to the extreme density of the artistic feature films now being produced, more than half of these films are also toned or tinted. This reduces the screen illumination still further by an amount varying from 40 to 90 per cent. Projection equipments which could project very satisfactorily the motion picture play of four years ago, cannot give the same satisfaction with recent films without at least doubling the available light. The high power arc arriving as it has at just about the same time as the dense artistic tinted feature film will solve the problem of maintaining satisfactory projection in the large houses by more than doubling the available light and also by rendering the color tinted films in brilliant true colors, due to the pure white quality of the high power arc.

THE HIGH INTENSITY ARC LAMP

The remarkable record of engineering progress in the motion picture industry for many years marked little improvement in the light source used for the projection of the completed picture. During that period, the motion picture had passed from an adventure to an industry. Producers had equipped studios to secure unusual photographic and scenic effects. Exhibitors had built theatres which were unrivalled in magnificence. The only notable change in the arc used for projection was a gradual increase in current to satisfy the longer throws, the added house lighting and the general demand of the public for a brighter picture. Arc amperes increased from 35 to even 150 with no compensating development along the lines of greater efficiency in light utilization or in light production.

With the old style projection arc, the increase in current beyond a certain point does not result in proportionate increases in light. High current arcs were difficult to control and projection reached a point where a radical change was necessary if screen intensities were to continue to increase. Efficiency itself could no longer be neglected. Power bills for high current arcs are an item of maintenance sufficiently great to merit attention. The engineering problem, then, was to evolve a light source of higher intensity, which had a higher utilization factor, which consumed less energy per lumen produced and which might

bring such added benefits as ease of operation and truer color values.

Fortunately, a development of 1914 pointed a way to this end. In July of that year, Heinrich Beck brought to this country an arc lamp which, for the same current that had heretofore been used, gave from three and a half to four times the amount of light. The principle of the lamp was the employment of uncommonly small electrodes, the positive having a highly mineralized core. In the operation of this lamp, the positive electrode was rotated about its axis and the negative electrode was placed at an angle to the positive in such relation that the negative flame drilled a deep crater into the face of the positive electrode. This crater was filled with the vapor of the minerals of the core and emitted an astonishingly high light flux. This lamp and its derivatives are now known as high intensity lamps, the term "high intensity" covering both the intense light flux and the high current density which results from the employment of the exceedingly small electrodes. The General Electric Company, recognizing the high merits of this lamp, bought the United States patents covering it.

The first application of this lamp was for searchlights, and as such it was used extensively both by Army and Navy during the war. Its industrial application did not come until later. In the motion picture industry lamps of this principle first appeared in studios for spot, flood and even general lighting.

The five years' experience in the operation of high intensity lamps in the searchlight field settled beyond question the practicability of such a

device and when the demand came for a more powerful illuminant in the motion picture projection field, it was only necessary to adapt the standard mechanism to meet the new conditions.

The first step was the selection of an appropriate current rating. It was known that the most popular average rating of projection arcs among the better class theatres was 75 amperes. It was decided that lower current might prove helpful and it was conceded that a relatively small percentage of theatres could utilize higher currents. The first model was built, therefore, for an average current consumption of 75 amperes.

Since this was the exact rating of the 24-inch high intensity searchlight, it was known that 11 m.m. carbons produced the maximum effect at this current. Also, the burning rate of both positive and negative carbons was known which established the gear ratios in the automatic feeding mechanism.

The problem then resolved itself into (1) the positioning of the crater with respect to the condensers to obtain the greatest possible utilization of the light produced; (2) the design and arrangement of operating parts to form a simple, reliable mechanism.

In searchlight practice, the horizontal positive carbon faced a mirror which reflected the light back through an opening in the rear of the housing. For projection purposes, it was decided to eliminate the mirror and face the arc directly into the condensers. The positive carbon was in the horizontal plane and the negative at an angle of 60 degrees. The distance from the arc to the con-

denser was limited to a minimum of 3½ inches to prevent excessive breakage. The 1/50 H.P. motor which was used to revolve the positive carbon was also enabled by an ingenious system of gearing to feed both positive and negative carbons.

Since it was possible to calculate the burning rate of the carbons to a fairly exact degree, it was also possible to select wear ratios which would maintain a constant rate of feed. As an additional precaution, the small motor was connected directly across the arc rather than to an outside source of supply. If the arc length increased the motor speed increased, consequently the rate of feed increased and vice versa. This is not sufficiently accurate in searchlight work where the arc must remain correctly focused with respect to the reflector within 1/64 inch. In motion picture projection, however, the requirements were not so exacting, the periods of operation were shorter and the simplification of operating detail seemed to outweigh the other considerations. No electrical, mechanical or thermostatic focal control devices were inserted. Hand controls were superimposed upon the motor feed so that the arc length could be corrected manually. In actual experience, it has been proven that no hand adjustments are necessary during the projection of a reel.

The results attained in commercial operation verify the laboratory calculations. The screen intensity is almost exactly twice as great as an old-fashioned arc at the same current. The color more nearly approximates the characteristics of daylight and there is a better color relation in color films and a better definition in black and

white prints. From an operating standpoint, the adjustments have been simplified to a point where it is practically automatic.

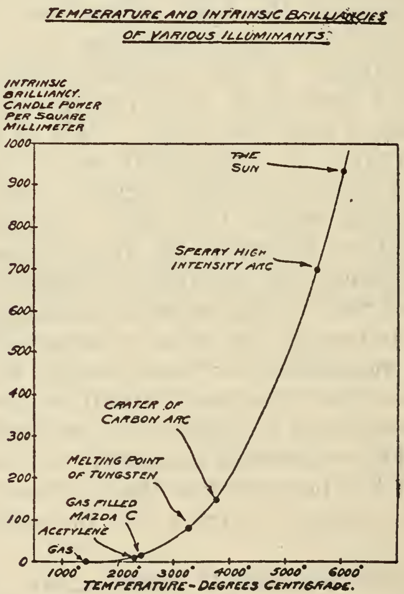


FIG. 335

THE SIMPLEX HIGH-INTENSITY ARC

The high-intensity arc, as furnished by the Precision Machine Company, Inc., manufacturers of the Simplex projector, is unparalleled in simplicity and efficiency of operation and the screen results are unequalled. One word fully describes the function of the high-intensity arc, and that word is—LIGHT. The World War saw the necessity for a searchlight of tremendous candle power and consequently great intensity. The present Simplex high-intensity lamp is a similar lamp reduced to meet projection requirements. Light in ample quantity has been constantly sought by projectionists and exhibitors of motion pictures and in the Simplex high-intensity lamp you can have it in all sufficient quantities.

The Simplex high-intensity lamp known as Type "A" is of the constant feed type, or perhaps a better term would be equipped with a mechanical control. The Type "A" lamp is substantially built, provided with all the necessary adjustments for centering the light and the optical system. The driving force or control is the well-known Simplex mechanical arc control. This unit provides for the feeding of both the positive and negative carbons and at the same time rotates the positive carbon constantly so as to keep the tip of the crater burning evenly. The ratio is approximately two to one and this refers of course to the feeding of the positive and negative carbons.

Provision is made for increasing or decreasing the speed of the carbon feed. There is absolutely nothing complicated about this lamp and any one with average experience can use it. The connections are the same as on any regular or low-intensity lamp and there are no parts to get out of order excepting wear and tear on the excessively heated parts. Every inch of the unit is open to the naked eye so that inspection and clean-

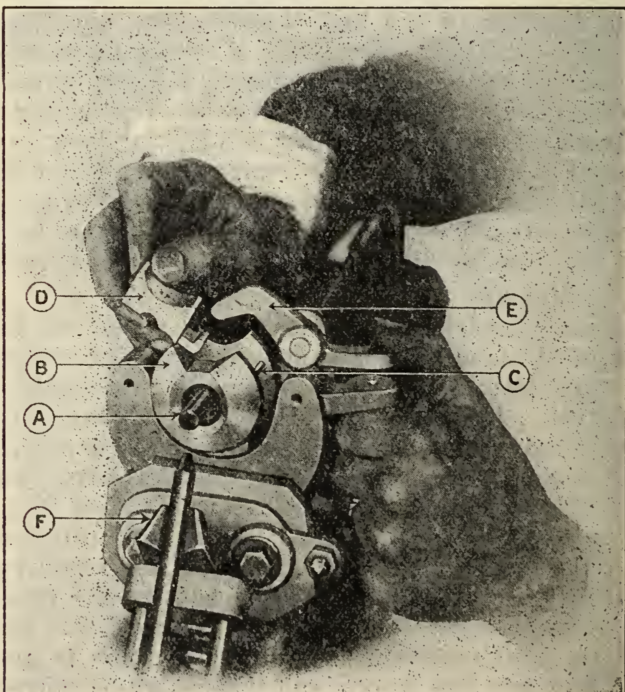


FIG. 336

ing are easily accomplished. The lamp is simplicity itself.

The normal arc voltage for this lamp is from 55-65 volts. It should be noted that the constant feed lamp is more reliable because this type gets its motive power from a constant source or that of the projector motor. The lamp is entirely automatic after the arc is struck and is very easily recarboned.

There are three different ratings—50 amperes, 75 amperes and 100 amperes. The carbon trims used are as follows:

50 ampere trim, positive, 9 millimeter x 18″, negative 5/16 x 6″, 100 ampere trim, positive, 13.6 m.m. x 18″, negative, 3/8″ x 6″; 75-ampere trim, positive 11 m.m. x 18″, and negative 11.32 x 6″.

The Simplex lamp will operate on alternating current in emergencies, although the manufacturer does not specify them for regular A. C. service. To obtain the advantages of the big improvement given by the high-intensity lamp, the installation of a motor generator set or D. C. line to the house is necessary. The high-intensity lamp is a new source of light in the projection field. It is a special form of flame arc and is at all times quiet and non-hissing. When the carbons are burned at their normal ampere rating the color of the light is whiter than the carbon arc and projection with it makes the plain carbon arcs appear golden in comparison to its pure silver white hue. The carbons are made especially for use in high-intensity lamps only.

Figure 337 is a general view of the Type "A" lamp removed from the housing. The positive carbon is inserted through part 2 and on through the positive nose cap part —. The broad head screw on part 2 is tightened so that as the positive carbon rotates it is also carried forward by means of the feed screw 4. The negative carbon is inserted in part No. 20 and secured by screw No. 21. The top of the negative carbon rests in the trough of part No. 22. After the lamp is carboned by means of hand feeding the carbon points should be brought very nearly together. To strike, the user grasps negative feed handle No. 33, then pulls the negative carbon up into contact with the positive, which strikes the arc. This action should be by means of a quick hard pull and as soon as the arc is struck, handle No. 33 should be released and it will automatically fall back into its proper position.

Principal parts which should be kept in stock are:

2 Upper contacts.
2 Positive nose caps.
4 Negative springs.
1 Negative carbon clamp screw.
4 Negative carriage leads.

GENERAL INSTRUCTIONS FOR OPERATING

I. Do not expect results from this type lamp if you use the wrong kind of carbons, upper or lower, or if you run the carbons at a higher or lower current value than that for which the carbons were designed.

II. Do not forget that arc length, that is, the distance between the tips of the carbons, makes

a difference in the burning of the arc, steadiness, amount of light, and even in the quality or color of the light.

III. *Proper Carbons:* Use white flame high-intensity trims only for the various currents as follows:

90 to 115 amps., 50 to 65 volts, 13.6 mm Pos. (upper).
60 to 80 amps., 40 to 55 volts, 11 mm Pos. (upper).
50 to 60 amps., 40 to 45 volts, 9 mm Pos. (upper).
Negative, (lower) carbons, cored (cannot use solids).
90 to 115 amps., 50 to 65 volts (arc) 3/8″ coated.
60 to 80 amps., 40 to 55 volts (arc) 11/32″ coated.
50 to 60 amps., 40 to 45 volts (arc) 5/16″ coated.

IV. *Proper Current:* You may hear of operators running up to 125 amps. with a 13.6 mm. positive, or up to 90 amps. with a 11 mm. positive; but remember, they do this at their own risk. The manufacturer will not stand behind the high-intensity lamp if run at higher currents and arc voltages than those given for the various carbons in paragraph III.

In the high-intensity lamp, when run with the proper carbon current and arc voltage, the positive carbon becomes white hot for a distance of about ¾ inch back of crater, that is, back to the contact nose or shoe. If run at a current greater than that for which the carbons are rated, the positive carbon becomes white hot for a distance of from 1″ to 2″ back from the crater, or to such an extent that the whole contact surfaces of the contact nose and shoe are bearing on the incandescent carbon with the result that the parts melt and burn away in a few days, where under normal conditions they should last for several months. If the contacts are thus overheated, it follows that they in turn conduct excessive heat to all parts

of the burner and give the operator no end of trouble. By running the carbons above their rating, you gain slightly in illumination, but you have an unmanageable arc and you cannot hope to get uniform results. The amount of light you gain is not worth the trouble and expense of the more frequent replacement of parts, and it has been found impossible to keep condensers from breaking where too high current is used or where generators cause great fluctuations during the run or in changing over on reels.

CHECK UP YOUR AMMETER

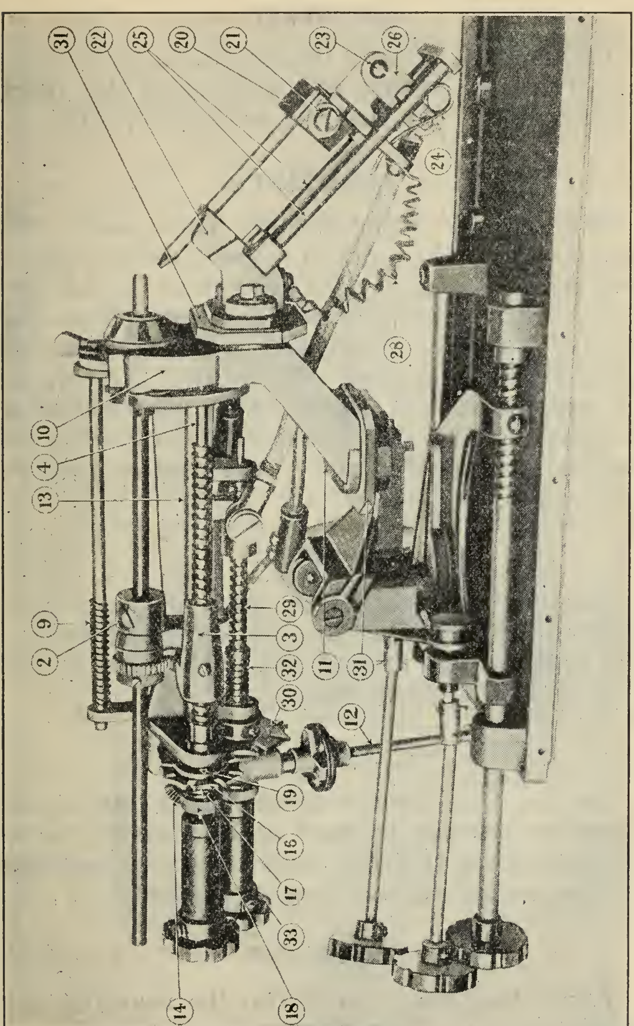
The best instruments sometimes, and the cheaper ones very often, indicate incorrectly. Sometimes they are "off" 10 amps. or more. It is best, especially when used in connection with high-intensity lamps, to have them checked against an instrument known to be correct.

ARC VOLTAGE

The voltage measured across the lamp terminals when the arc is burning should not exceed those given in paragraph III. Too great an arc length, that is, too high arc voltage, does not increase illumination, but increases the heat around the arc, causes a long unsteady arc flame and gives a bluish tint to the light on the screen.

CONTACTS AND CONNECTIONS

It is of great importance to see that there is good wiping contact on the positive carbon. The highest temperature of the lamps is at the contact shoe or head guiding the positive carbon and therefore this part must be constantly watched.



Simplex High Intensity Arc

FIG. 337

IMPORTANT

Be sure that there is tension on the upper contact from the spring acting through the upper contact lever. See that the lever is not stiff.

IMPORTANT

Remove the upper contact once every two days and with the point of a screw driver remove any scale or loose dirt in the bottom of the "V" in the contact of B. Fig. 336 and also remove any obstruction which might tend to hold contact shoe away from the carbon. Every time you retrim the positive carbon, pay attention to whether or not the upper contact B. Fig. 336 is raised as the carbon is shoved in and if the contact rubs on the carbon.

IMPORTANT

See that the brass ribbon leads on the positive head and upper contact are held tight with a screw and brass washer at each end, so that they will be sure of making good contact.

NEGATIVE CONTACT

Be sure that the corrugated brass lead on the negative carriage is tight at both ends. Loose connection on this lead will cause the negative spring to overheat and lose its tension.

IMPORTANT

Every time that you retrim the negative, pay attention to the following:

I. See that no copper coating from the carbon has lodged in the "V" of the negative guide head to hold the carbon out. Any scale in this "V" can be chipped out with the point of a screw driver.

II. Be sure that the carbon clamp grips the carbon tightly. See that there is spring tension enough on the carbon holder to hold the negative carbon firmly into the "V".

III. After tightening up on the negative carbon, feed it up by means of the head feed-crank until its tip nearly touches the end of the positive carbon. If it is properly in line, it will point directly at the center or core of the positive. If it does not, the cap screws holding the negative guide head must be loosened slightly and the head twisted over until carbons are exactly in line. You cannot get results with the carbons out of line.

IMPORTANT

Do not use oil on any part of the burner (any part of the lamp located inside lamp house), because, on account of the heat it will cake and cause moving parts to bind. Use only graphite grease. It is preferable to put this lubricant on when the lamp is hot so that it will melt and run into the bearings.

When the lamp is assembled at the factory, every screw in the burner gets a coating of graphite. If you have occasion to remove any screw on the burner, put graphite on the threads when you replace it.

CAUTION

In using graphite on the lamp, be careful not

to get any of it on the insulating plates, washers or bushings. Graphite is a conductor of electricity and would be apt to cause short circuits. Do not use too much lubrication—just enough to keep moving parts running smooth and easily without squeaking. Do not test for squeaks in the lamp with a positive carbon in the holder.

CARE OF LAMP

See that all screws and nuts, especially on the burner, are tight. Any screw or nut clamping on a lead or a contact must be tested with a wrench or screw driver from time to time to see that they stay tight. On such apparatus as a lamp that runs hot, screws and bolts are constantly loosening up and if not tightened in time may cause no end of trouble. The hex head bolts holding the negative head must be watched closely. If they loosen up, which they will in time on account of the insulation washers shrinking because of the heat, the negative will get out of line with the positive. Don't let dirt accumulate on the burner.

Tools—Don't try to tighten up hexagon nuts and screws with a pair of gas pliers. For a few cents you can obtain open-end wrenches for this purpose. For all hex. nuts and screws on the lamp the following wrenches will do: ½″ opening and 9/16″ opening.

Do not run too long an arc. Boost your generator voltage to get the desired current or manipulate your rheostat. See paragraph III of these instructions.

By way of general explanation it should be ex-

plained that the feeding rod, which is rotated by means of the mechanical arc control, serves three purposes. First, in driving the positive feed handle through a star, actuated by a two-pin cam; second, feeds the negative carbon by means of a star, actuated by a one-pin cam, with a ratio therefore of two to one; and third, constantly rotates the carbon as mentioned before.

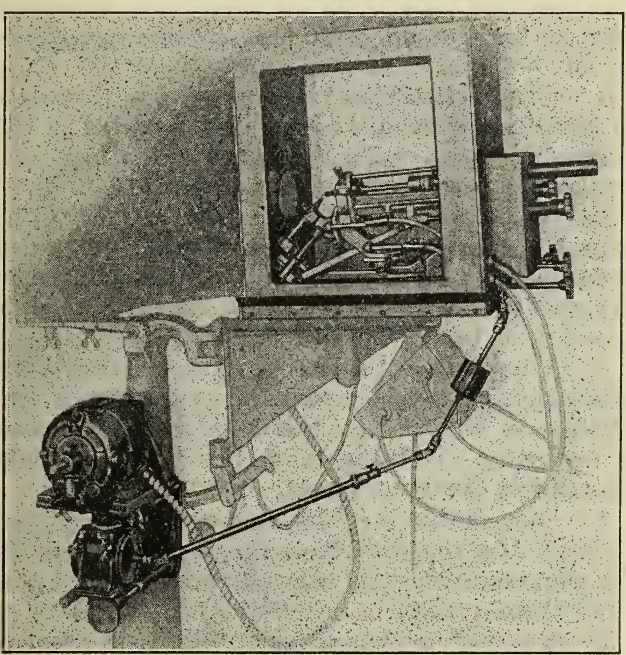


FIG. 338
Simplex High Intensity with Automatic Arc Control

GENERAL ELECTRIC HIGH INTENSITY MOTION PICTURE PROJECTON LAMP

GENERAL

The high intensity lamp has several marked changes over the old style carbon lamp generally used in projection machines. These are briefly as follows:

1. The carbons used are considerably smaller in diameter as compared with the carbons of the old style lamps for the same current rating. The positive (upper) carbon has a large core composed of metallic salts which, when used with the proper negative (lower) carbon in the correct position, burns away, forming a deep crater in the positive carbon in which is contained a quantity of highly luminous gas.

2. The positive (upper) carbon is rotated continuously and is located on the optical axis. No vertical or horizontal adjustment of this carbon is necessary after the lamp has been correctly installed in the lamp house.

3. *Current to the positive carbon is carried through the contacts near the arc.* Current to the negative carbon is carried through the negative carbon clamp.

4. The carbon clamps are insulated to prevent current passing through the feed screws.

5. The carbons are fed ahead at a predetermined rate by the motor under the base plate of the lamp and hand feed handles are provided for

correcting the position of the carbons when necessary. The motor armature and field are connected directly across the arc tending to compensate for fluctuations of the arc voltage.

The positive (upper) carbon is held tightly in the clamp on the positive feed screw. This screw is rotated with the carbon carriage by the bevel gear and pinion which are connected to the motor through a worm and worm gear. A star wheel attached to the feed screw revolves with the carriage around the axis of the carbon and during each revolution engages with the detent fastened to the support for the lamp. This advances the star wheel one tooth for each revolution of the carriage, revolving the feed screw and feeding the carbon ahead. The positive tube and knob revolve with the carriage and a spur gear fastened to the tube meshes with a spur gear on the feed screw. Each time the detent advances the star wheel, the positive tube and the knob also advance, this allowing the operator to check the feeding operation.

By advancing or retarding the rotation of the knob the positive (upper) carbon may be moved ahead or back.

The negative (lower) carbon is held tightly in the negative carbon lamp on the feed screw. This screw is rotated by the bevel gears driven by the motor through a worm and worm gear. The negative feed shaft extends through the rear of the lamp house, and the carbon may be fed ahead or back by turning this shaft clockwise or counter clockwise.

Slip clutches are provided on the positive and negative feed rods so that the negative (lower)

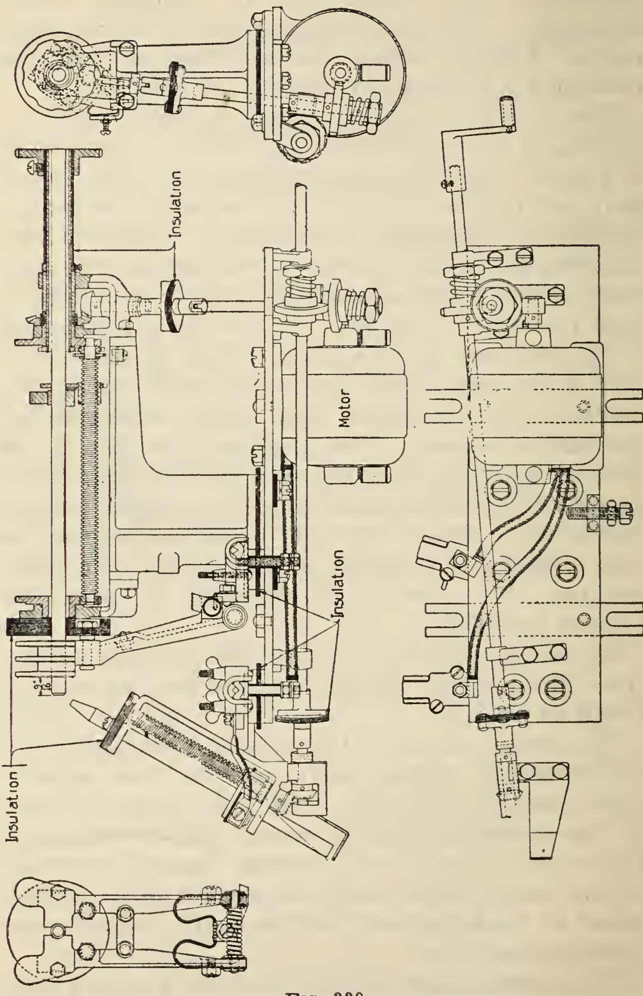


FIG. 339

carbon may be fed ahead or back and that the positive (upper) carbon carriage may be rotated by hand, when the motor is not running. The pressure on the springs on the slip clutches should be great enough to drive the feeding mechanism but should allow slipping if the carbon clamps are at the end of the carriage.

The projection lamp is installed in the lamp house by the manufacturer of the projection machine. Since the lamp may shift during shipment from the correct position, check the alignment by entering a gauge rod the size of the positive carbon through the positive carbon tube.

The diameter of this gauge rod is as follows:

50 ampere lamp—	9 mm. or	11/32 in.
75 ampere lamp—	11 mm. or	7/16 in.
100 ampere lamp—	13.6 mm. or	17/32 in.

Remove the condensing lenses and push the rod forward until the point is about even with the aperture plate. Move the lamp vertically and horizontally by means of the adjustments provided until the point of the gauge rod is in the center of the aperture.

Current and Voltage (*Form A-3*, 50 *Ampere, see Name Plate of Lamp*)

This lamp is rated at 50 amperes direct current and 50 to 55 volts at the arc and the rheostat should be set to give this current and voltage. (No adjustment is necessary when the current is supplied by a General Electric motor-generator compensarc or similar machine.) This lamp must not be operated at less than 45 amperes or more than 55 amperes.

Current and Voltage (*Form A*-1, 75 *Ampere, see Name Plate of Lamp*)

This lamp is rated at 75 amperes direct current and 55 to 60 volts of the arc and the rheostat should be set to give this current and voltage. (No adjustment is necessary when the current is supplied by a General Electric motor-generator compensarc or similar machine. This lamp must not be operated at less than 70 amperes or more than 80 amperes.

Current and Voltage (*Form A*-4, 100 *Ampere, see Name Plate of Lamp*)

This lamp is rated at 100 amperes direct current and 65 to 70 volts at the arc and the rheostat should be set to give this current and voltage. (No adjustment is necessary when the current is supplied by a General Electric motor-generator compensarc or similar machine.) This lamp must not be operated at less than 95 amperes or more than 105 amperes.

Carbons—The following carbons should be used with these lamps:

	50 AMPERE	75 AMPERE	100 AMPERE
Positive (upper)	9 mm. dia. 18. in. long	11 mm. dia. 18 in. long	13.6 mm. dia. 18 in. long
Negative (lower)	$\frac{11}{32}$ in. dia. Cored Silver-tip 9 in. long	$\frac{3}{8}$ in. dia. Cored Silver-tip 9 in. long	$\frac{7}{16}$ in. dia. Cored Silver-tip 9 in. long

Carboning—Turn the negative and positive feed handles counter-clockwise until the carbon clamps are at the extreme rear position. If the detent is engaged with the star wheel rotate the positive carriage slightly by turning the insulating coupling on the positive feed shaft. Push the negative (lower) carbon through the guide from the top allowing it to rest at the stop at the bottom of the head. Tighten the clamp screw with sufficient pressure to grip the carbon. Push the positive (upper) carbon through the tube at the rear of the lamp house allowing it to project 9/16 in. beyond the contacts. Tighten the clamp screw with sufficient pressure to grip the carbon. Adjust the focusing screw at the back of the lamp house until the distance from the end of the positive (upper) carbon to the face of the rear lens is one-half the focal length of the lens.

OPERATION

Lamps in Multiple—Closing the lamp switch starts the motor and rotates the positive (upper) carbon. Turn the negative feed handles clockwise until the carbons touch lightly and immediately reverse until the arc is approximately ⅜ in. long. This should give an arc voltage as follows:

Amperes	Arc Voltage
50	50 to 55
75	55 to 60
100	65 to 70

No further attention is necessary unless the arc length varies considerably. If this is due to uneven burning of either carbon, move the carbons ahead or back turning the handles clockwise or counter-clockwise respectively.

If the positive (upper) carbon regularly feeds too fast or too slow or does not feed, it may be that the star wheel does not engage with the detent; check this to see that the detent engages with one tooth during each revolution of the carriage. This may be checked by the "kick" given the positive feed knob once every revolution when the lamp is feeding. The detent may be adjusted to secure the proper rate of feeding by the screw in the bracket supporting the detent.

To shut down, open the lamp switch. The lamp will burn approximately one hour with one setting of the clamps. However, after each reel the clamps should be returned to the rear end of the feed screws and the carbons pushed through to the correct position. When the carbons are too short to run the required time they should be removed and new carbons inserted. The positive carbon is consumed at the rate of approximately 6 inches per hour, the negative carbon at the rate of approximately 2¾ inches per hour.

Lamp in Series—Bring the carbons together lightly, close the lamp switch and open the short circuiting switch. Allow the carbon points to heat up and then draw the arc.

To shut down, bring carbons together, close short circuiting switch and open lamp switch.

Read also instruction given above under "Operation (Lamps in Multiple)."

Emergency on Alternating Current—When these lamps are used with a General Electric motor-generator compensarc or similar machine, there is a possibility of current failure on the line supplying the motor-generator. In such a case, it is sometimes necessary to connect the lamp to the emergency a. c. line through an a. c. compensarc or similar device. As the motor in the lamp is for d. c. operation, disconnect the motor by means of the switch on the lamp base and operate the lamp by hand feed.

The following table gives proper current and voltage at which to operate on alternating current:

50-ampere lamp—	50 to 55 amps.—	35 volts
75-ampere lamp—	70 to 73 amps.—	35 volts
100-ampere lamp—	105 to 108 amps.—	35 volts

CARE AND ATTENTION

Keep the Lamp Clean—The contacts must be inspected and cleaned each day to insure their making proper contact with the carbon. Inspect the spring between the contact levers and make sure that the tension does not become too weak. An extra set of contacts, springs and insulating guide plates on the positive and negative heads should be kept on hand for replacement.

Do not lubricate any parts of the lamp except the motor.

Contacts may be dismantled by removing the spring and link holding the two contacts.

Make sure that the scale from the coated carbons does not ground the positive contacts to the frame of the lamp.

Motor—Inspect the motor brushes at least once a month to see that they are wearing evenly. Keep the oil cups filled with a good grade of vaseline.

SUN-LIGHT ARC TYPE "C" AUTOMATIC HIGH-INTENSITY PROJECTION LAMP

The Sun-Light Arc Type "C" Automatic Projection Lamp consists of two separate units—the lamp unit, which is mounted inside of the lamphouse, and the control unit, which is mounted outside of the lamphouse against its rear plate. The control unit consists of the magnets, ratchets, pawls, and the electric motor. These parts it is necessary to keep as cool as possible, and for this reason they are mounted outside of the lamphouse.

The lamp is mounted on an adjustable stand, so that the arc can be moved in all three directions for centering the light and the optical system. Each adjustment has stops located so that no part of the lamp can be swung too close to any part of the lamphouse.

Automatic operation is accomplished as follows: The small motor is connected across the arc terminals, operating continuously at arc voltage. This motor, through a worm gear, operates a crank, which, in turn, causes the rocker arm in the control to oscillate continually at about 100 oscillations per minute. This rocker arm carries three pawls, which make into three ratchets—one controlling the negative feed, one the positive feed, and one the rotation of the positive carbon. The negative pawl is normally out of engagement with the ratchet, but it is thrown into engagement by the negative feed magnets when the arc length,

and therefore the arc voltage, comes large enough to draw in the magnet armature. The negative feed magnet is a shunt magnet across the arc. It also has a few series turns differentially wound to compensate for changes of current in the arc lamp.

The positive pawl is also held out of engagement normally and is drawn into engagement by

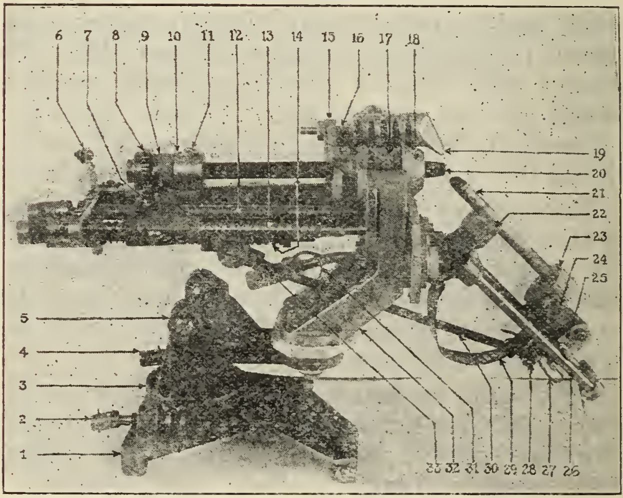


FIG. 340

the small positive feed magnet. This magnet is energized by a separate circuit called the third electrode circuit. The third electrode is a piece of half-inch copper rod mounted at an angle over the positive crater and insulated from both positive and negative. This copper rod is connected to one end of the positive feed magnet. The other

terminal of the feed magnet is attached to the positive side of the line. When the arc is burning normally, no current flows through this magnet, but as the positive crater burns away, the arc flame finally touches the end of the copper rod. The copper rod then draws from the arc through the flame a small shunt current, which energizes the magnet, pulls in the positive feed pawl and causes the carbon to be advanced, carrying the flame away from the copper rod, and thus breaking the magnet circuit. The maximum voltage to which this magnet is subjected is about 25 volts. It normally operates on from 10 to 15 volts.

The rotating pawl is held in continuous engagement with the rotating ratchet, thus imparting a constant rotation to the positive carbon necessary in keeping the lip of the crater burning evenly. The normal arc voltage is from 55 to 65 volts.

The lamp is made in three different ratings—the 50 ampere lamp, the 75 ampere lamp, and the 100 ampere lamp. The carbon trims used are as follows: 50 ampere trim, positive, 9 mm. x 18 in., negative 5/16 x 6 in. or 9 in.; 100 ampere trim, positive, 13.6 mm. x 18 in., negative, 3/8 in. x 9 in. or 3/8 in. x 6 in.; 75 ampere trim, positive, 11 mm. x 18 in., and negative 11/32 x 6 in. or 11/32 x 9 in., as preferred.

DESCRIPTION OF SUN-LIGHT ARC HIGH INTENSITY PROJECTOR LAMP

In order to use this new source of light for projection purposes, to its best advantage, it has been necessary to design a lamp mechanism

which contains many mechanical features that are entirely new in the art and which are fundamental improvements. The complete Sunlight Arc Automatic Projection Lamp has been designed as two separate units; the lamp unit and the automatic control unit.

The lamp unit complete is shown in Figure 340.

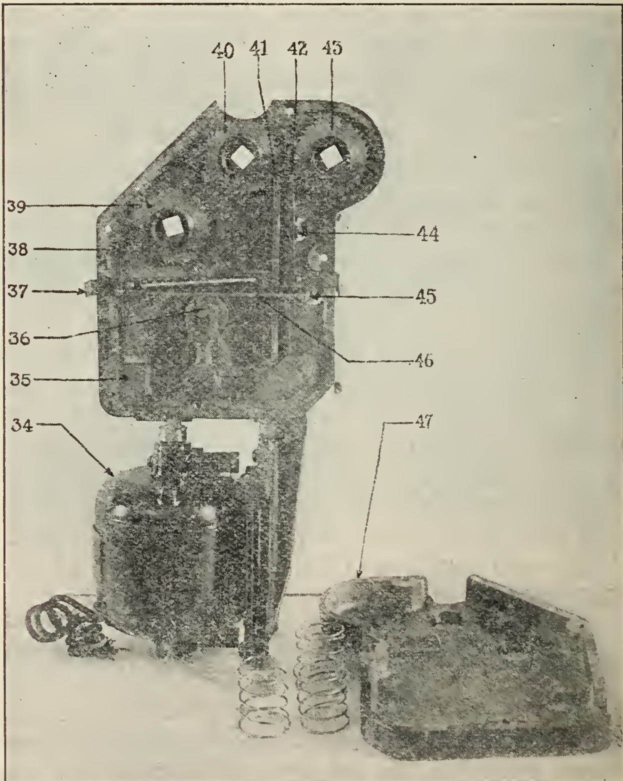


FIG. 341

It consists of the adjustable mounting, the carbon holders, contacts, and feeding screws. This whole unit is mounted in the lamp house. The adjustable mounting is a very simple device which allows for the universal adjustment of the arc in all three axes. This mounting consists of three parts: The base (1), the swivel stand (3), and the lamp-supporting bracket (5). The base is mounted on the focussing rod in the bottom of the lamp house, and is moved backward or forward by this rod for focussing the lamp. The swivel stand is turned on its axis by the adjusting screw (2). This gives the arc its lateral adjustment. Adjusting screw (4) raises or lowers the arc by pushing against the lamp-supporting bracket.

The lamp is mounted on the lamp-supporting bracket and is insulated therefrom. The main frame of the lamp (32) carries all of the lamp parts, both positive and negative, and is the only part of the entire lamp which touches the mounting or any other part of the lamp house. This feature simplifies the lamp insulation and makes the chances of short circuits more rare. The positive carbon (20), on account of the high current density at which it operates, cannot carry the current through its entire length. The current is applied within three-quarters of an inch of the positive crater through a heavy metal contact (18) and a spring-pressed metal brush (17). The spring (31) which pulls down on this brush is of the hairpin type, located away from the arc and away from all metal parts, in order that it may keep cool and retain its tension. The positive carbon is held at the rear end in carbon holder

(10) by means of set screw (11). This carbon holder is mounted in positive carriage (9), so that it may be rotated by gears (8) and (7). Gear (7) is keyed to the slotted shaft (12). This shaft is continuously rotated during the operation of the lamp and through the gears and the carbon holder, impart a slow, continuous rotation to the positive carbon. The feeding of the positive carbon is accomplished by moving the whole positive carriage (9) forward. The positive carriage is carried forward by the rotation of the positive feeding screw (13). This is not a continuous feed but acts automatically. The automatic feed of the positive carbon is accomplished by the new third electrode system. The third electrode (19) is a ribbed casting of heat-resisting alloy, which is mounted just over the positive carbon. It is insulated from both the positive and negative parts of the lamp by being held by the insulated bracket (15). The screw (16) allows of a fine adjustment of the position of the third electrode. An insulated wire (6) is carried back from the third electrode to the rear of the lamp where it connects with the automatic control unit. The operation of this system will be described under the automatic control unit.

The negative carbon (21) is mounted at an angle of 45 degrees to the positive. This carbon is not rotated but is fed by a lead screw (14) running parallel with the positive lead screw (13). This lead screw, by means of the traveling part (33) and the connecting rod (30), drags the negative carriage (25) along the guide rods (26). This feed rod is also operated automatically by a mechanism mounted on the control unit. The

negative carriage carries the negative carbon holder (23). Set screw (24) clamps the negative carbon in this holder. The spring (27) pulls down on the negative carbon holder. This causes the negative carbon to be pressed firmly into the shallow V-guide (22). This guide keeps the negative in perfect alignment and also supplies a portion of the current to the negative carbon near its burning tip. The remainder of the current is carried to the negative carbon through the flexible strap (29) to the negative carbon holder. Dividing the current in this manner prevents any overheating of the negative contact parts.

The Automatic Control Unit, as shown in Figure 341, is mounted outside the lamp house on the back plate. This unit contains the driving motor and all of the controlling mechanism for maintaining the arc entirely automatically in the desired position. The small motor (34) furnishes the power for the continuous rotation of the positive electrode and the intermittent feeding of both electrodes. The motor runs continuously on arc voltage. Through a worm gear reduction, the motor rotates crank (36). The crank causes the small rocker arm (35) to oscillate at a speed of about one hundred strokes per minute. This rocker arm carries three pawls (38), (41) and (42), which are lifted up and down with each stroke. Pawl (41) is held in continuous engagement with ratchet (40). This ratchet is connected by means of a square shaft to the positive rotating shaft in the lamp unit. The carbon is thus rotated all of the time that the motor is running. Pawl (42) is held normally just out of engagement with the positive feed ratchet (43).

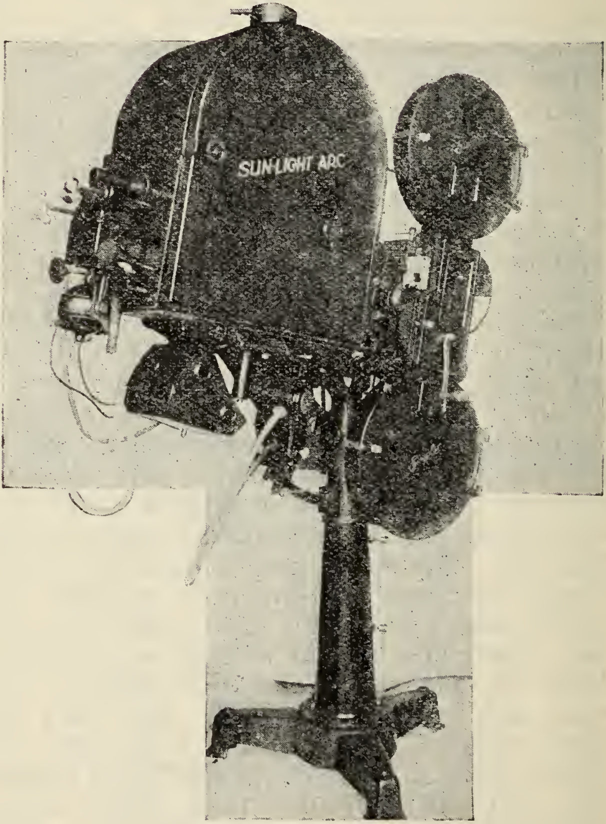


FIG. 342

This pawl, however, is brought into engagement with the positive feed ratchet by the armature (44) of the third electrode magnet. The magnet,

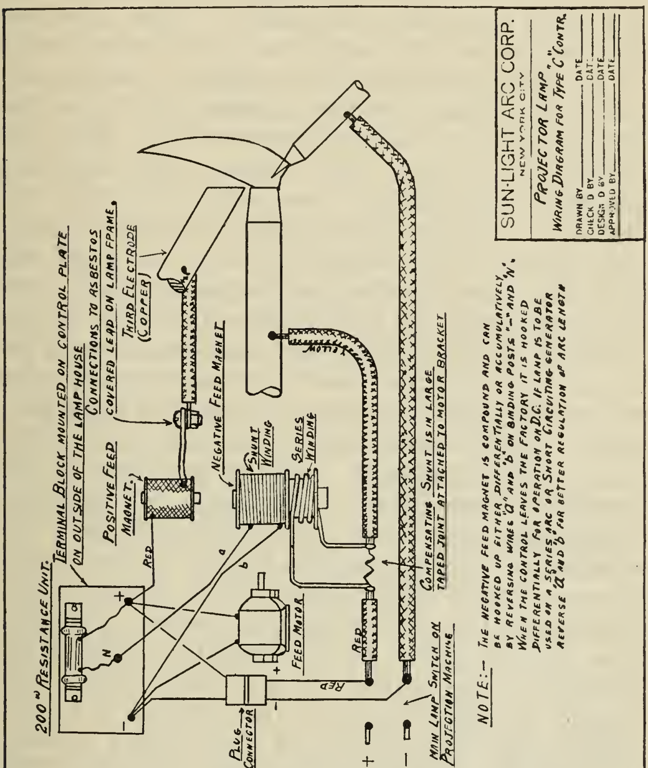


FIG. 343

being mounted on the back of the plate in Fig. 343 does not show. One terminal of the third electrode magnet is attached to lead (6) which is

carried back from the insulated third electrode on the lamp. The other end of the magnet is attached to the positive side of the line. Normally, no current flows through this magnet, since the third electrode is insulated. When, however, the positive crater burns back nearly to the tip of the third electrode, the arc flame, sweeping up above the crater, brushes against the tip of the third electrode. As this arc flame is a good conductor of current, this contact with the third electrode establishes a current flow from the flame to the electrode and thus through the feeding magnet. The magnet becomes energized and pulls the pawl into the positive feed ratchet. The positive carbon is then advanced slowly by the rotation of the ratchet and feed screw until the crater and the arc flame are carried to a point where the flame no longer touches the third electrode. This breaks the circuit and the feeding stops. The simplicity and the accuracy of this control is remarkable. It needs no attention whatsoever and once set, will always hold the crater in a certain position despite carbon variations or current fluctuations. It is, in reality, the first method of controlling a projection arc which may be truly said to be an automatic control of the position of the crater. It is to be noted that the crater is rigidly fixed in the vertical and horizontal axes on account of the carbon passing through the rigid lamp frame and contacts. This in combination with the third electrode control, fixes the position in the longitudinal axis and gives to the projectionist, for the first time, an arc source of light in which the crater is actually and definitely fixed at a certain point.

The negative feed is controlled by the voltage across the arc. The small voltage control magnet is mounted on the back of the mechanism plate. One terminal of this magnet is connected to the positive side of the line, the other to the negative side of the line. As the negative is consumed, the arc becomes longer and the arc voltage is increased. The increase in the arc voltage increases the pull of the negative control magnet and through the armature (45) and the connecting rod (46), draws the pawl (38) toward the ratchet (39). When the arc voltage increases sufficiently for the pawl to catch the ratchet, the consequent rotation of the negative feed ratchet and the screw feeds the negative ahead and shortens the arc until the voltage drops sufficiently to move the pawl out of engagement with the ratchet.

It should be noted that since the position of the positive is controlled, and the arc length is also controlled, that therefore, the position of the negative tip is controlled and we have an automatic arc which maintains both of its carbons within a thirty-second of an inch of their set positions for an entre trim of carbons, without any attention on the part of the operator. The rotating shaft and both feed shafts have auxilliary handles, so that at any time, the lamp may be operated by hand. A small slide bar (37) makes it possible to cut out the automatic feed of both carbons by holding the pawls out of the ratchets. The lamp may then be controlled by hand.

The pawl and ratchet mechanism, although easily accessible, is normally kept covered and protected by the cover (47).

GENERAL INSTRUCTIONS FOR OPERATING

Do not expect results from our lamps if you use the wrong kind of carbons, upper or lower, or if you run the carbons at a higher or lower current value than that for which the carbons were designed.

Do not forget that Arc length, that is, the distance between the tips of the carbons, makes a difference in the burning of the arc, steadiness, amount of light, and even in the quality or color of the light.

PROPER CURRENT:

You may hear of operators running up to 125 Amps. with a 13.6 mm Positive or up to 90 Amps. with a 11 Positive; but remember, they do this at their own risk. Neither the Sun-Light Arc Corp. nor any other company will stand behind the high intensity lamp if run at higher currents and arc voltages than those given for the various carbons above.

In the high intensity lamp, when run with the proper carbon, current and arc voltage, the positive carbon becomes white hot for a distance of about ¾ inches back of crater, that is, back to the contact nose or shoe. If run at a current greater than that for which the carbons are rated, the positive carbon becomes white hot for a distance of from 1 in. to 2 in. back from the crater, or to such an extent that the whole contact surfaces of the contact nose and shoe are bearing on the incandescent carbon with the result that the parts

melt and burn away in a few days, where under normal conditions they should last for several months. If the contacts are thus overheated, it follows that they in turn conduct excessive heat to all parts of the burner and give the operator no end of trouble. By running the Carbons above their rating, you gain slightly in illumination but you have an unmanageable arc and you cannot hope to get uniform results. The amount of light you gain is not worth the trouble and expense of the more frequent replacement of parts, and it has been found impossible to keep condensers from breaking where too high current is used or where generators cause great fluctuations during the run or in changing over on reels.

CHECK UP YOUR AMMETER:

The best instruments sometimes, and the cheaper ones very often, indicate incorrectly. Sometimes they are "off" 10 Amps. or more. It is best, especially when used in connection with high intensity lamps, to have them checked against an instrument known to be correct.

ARC VOLTAGE:

The Voltage measured across the lamp terminals when the arc is burning should not exceed those given in paragraph III. Too great an arc length, that is, too high arc voltage does not increase illumination, but increases the heat around the arc, causes a long unsteady arc flame and gives a bluish tint to the light on the screen.

CONTACTS AND CONNECTIONS:

It is of great importance to see that there is good wiping contact on the positive carbon. The highest temperature of the lamps is at the contact shoe or head guiding the positive carbon and therefore, this part must be constantly watched.

IMPORTANT:

Be sure that there is tension on the upper contact 5-4 from the spring 5-5 acting through the upper contact lever. See that the lever is not stiff where it is pivoted.

IMPORTANT:

Remove the upper contact 5-4 once every two days and with the point of a screw driver remove any scale or loose dirt in the bottom of the "V" in the contact of No. 5-3 and also remove any obstruction which might tend to hold contact shoe away from the carbon. Every time you retrim the positive carbon, pay attention to whether or not the upper contact 5-4 is raised as the carbon is shoved in and if the contact rubs on the carbon.

IMPORTANT:

See that the brass ribbon leads on the positive head and upper contact are held tight with a screw and brass washer at each end, so that they will be sure of making good contact.

NEGATIVE CONTACT:

Be sure that the corrugated brass lead on the negative carriage is tight at both ends. Loose

connection on this lead will cause the negative spring to overheat and lose its tension.

IMPORTANT:

Every time that you retrim the negative, pay attention to the following:

I. See that no copper coating from the carbon has lodged in the "V" of the negative guide head to hold the carbon out. Any scale in this "V" can be chipped out with the point of the screw driver.

II. Be sure that the carbon clamp grips the carbon tightly. See that there is spring tension enough on the carbon holder to hold the negative carbon firmly into the "V."

III. After tightening up on the negative carbon, feed it up by means of the hand feed-crank until its tip nearly touches the end of the positive carbon. If it is properly in line, it will point drectly at the center or core of the positive. If it does not, the cap screws holding the negative guide head must be loosened slightly and the head twisted over until carbons are exactly in line. You cannot get results with the carbons out of line.

FOR LUBRICATION on lamp use Dixon's No. 691 Cycle Chain Grease.

IMPORTANT:

Do not use oil on any part of the burner (any part of the lamp located inside lamp house), because, on account of the heat it will cake and cause moving parts to bind. Use only graphite grease, or Dixon's Graphite Stick Compound, and it is preferable to put these lubricants on when the lamp is hot so that they will melt and run into the bearings.

Burner Lubrication:

Use graphite grease every two days on the positive and negative feed worms, the guide rods for the negative carriage, the positive rotating gear, teeth and bearings.

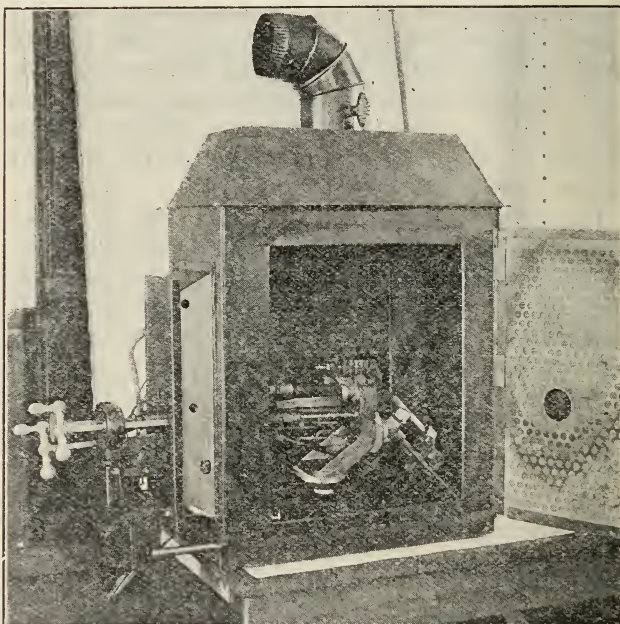


Fig. 344

Important:

Occasionally, the large set screw holding the 3rd electrode collar should be completely removed and the threads lubricated with graphite. This also

applies to the negative carbon clamping screw. If this is done, these important screws will never "freeze" in and break off when you try to tighten them.

When the lamp is assembled at our factory every screw in the burner gets a coating of graphite. If you have occasion to remove any screw on the burner, put graphite on the threads when you replace it.

CAUTION:

In using graphite on the lamp be careful not to get any of it on any of the insulating plates, washers or bushings. Graphite is a conductor of electricity and would be apt to cause short circuits. Do not use too much lubrication—just enough to keep moving parts running smoth and easily without squeaking. Do not test for squeaks in the lamp with a positive carbon in the holder, for with proper contact and spring tension on the upper contact, you will find that the carbon squeaks as it rotates in the head.

LUBRICATION OF CONTROL UNIT:

Gear Case—See that the worm gear case on the back of the control unit is properly lubricated. Use motor grease or light cup grease. Do not put graphite in gear case. The case is filled through the plug No. 110 on blue print.

Motor Cups—Fill with regular motor cup grease, not vaseline, every two months. Do not pour lubricating oil on motor bearings as it will run down and damage motor windings.

Inside of Control—Put a little heavy grease in eccentric pin slot on rocker arm No. 113 and oil the rocker arm pivot screw. Do not oil pawls or ratchets. Do not fill the control box up with grease as this will tend to interfere with the free action of the pawls.

CAUTION:

Do not oil armature bearings or any part of the feed magnets.

CARE OF LAMP:

See that all screws and nuts, especially on the burner, are tight. Any screw or nut clamping a lead or a contact must be tested with a wrench or screw driver from time to time to see that they stay tight. On such apparatus as a lamp that runs hot, screws and bolts are constantly loosening up and if not tightened in time may cause no end of trouble. The hex head bolts holding the negative head must be watched closely. If they loosen up, which they will in time, on account of the insulation washers No. 71 shrinking because of the heat, the negative will get out of line with the positive. Don't let dirt accumulate on the burner.

IN GENERAL:

Carry enough spare parts to take care of any emergency. We would suggest that the following be always on hand in the booth:

2 No. 3 Positive nose cap
2 No. 4 Upper contacts
4 No. 5 Upper contact springs
2 No. 15 Third Electrodes

1 No. 64 Neg. Carbon clamp Screw
4 No. 65 Neg. Carriage Leads
3 No. 34 Feed rod insulation couplings
2 No. 00 Motor Brushes and Springs
1 Set of all lamp insulations.

Order spare parts by number, numbers to be taken from our drawing No. 5000 which we furnish with each outfit.

Tools—Don't try to tighten up hexagon nuts and screws with a pair of gas pliers. For a few cents you can obtain open end wrenches for this purpose. For all hexagon nuts and screws on our lamp the following wrenches will do: ½ in. opening and 9/16 in. opening.

Do not run control on more than normal arc voltage for any length of time. It would overheat motor and coils.

Do not run too long an arc. Boost your generator voltage to get the desired current or manipulate your rheostat.

Study diagram on page 847 so that you may become familiar with action and setting of the third electrode. The third electrode controls the feed of the positive carbon and may, therefore, be called the "self-focusing feature of the lamp." Its setting affects the burning of the arc, so by learning just what is the best setting, you will save yourself much trouble.

THIRD ELECTRODE CONSUMPTION:

The third electrode functions to feed the carbon by reason of the arc flame touching its tip and

thereby closing the circuit through the positive feed magnet. (See wiring diagram page 847.) By reason of its proximity to and frequent contact with the flame it is constantly being consumed and will have to be replaced. We estimate that the life of one of these electrodes on a lamp using 115 Amps. should be above six weeks.

POWER'S "G-E" HIGH INTENSITY ARC LAMP

Power's "G-E" lamp produces upon the screen over one hundred per cent more light per ampere than the ordinary arc lamp, and is undoubtedly today the foremost development in the motion picture projection field. High intensity illumination, as at present understood, is based upon foreign researches—and inventions known as the Beck patents, taken over and developed for search-light during the war by the General Electric Company. This illumination was so satisfactory the General Electric Company and the Nicholas Power Company have now developed the Power's "G-E" high intensity arc lamp for motion picture projection, and this has proved highly successful after over fifteen months' practical operation in a large number of representative American theatres.

Power's "G-E" high intensity arc lamp is a radical departure from the ordinary arc lamp. The intensity of the illumination and the quality of light developed are the result of several novel mechanical features incorporated in the new lamp and the chemical nature and construction of the core and wall of the high intensity carbon. A reference to the accompanying cut shows the general appearance of the high intensity lamp. The center of the core of the positive carbon is exactly on the optical axis of the projection equipment, while the negative carbon is set at an angle of about 55 degrees to it. The ordinary carbon set

in this way would give possibly 10 to 20 per cent more light than the setup of the ordinary arc lamp.

The mechanical design of the high intensity lamp permits the maximum amount of light to be gathered by the condensers, and this means a considerable saving in the cost of current consumption. While in some instances this might not be the most important consideration, it must be understood that if the same amount of light were desired from the ordinary arc lamp, this would be difficult without great additional expense, and the quality of the light absolutely depends upon the proper use of the high intensity lamp and high intensity carbon.

The positive (upper) carbon is 18 inches long and uncoated, and the negative (lower) carbon is 9 inches long and metal coated. Both have a much smaller diameter than ordinary carbons. If the normal rated operating current were carried through the entire length of the positive carbon, it would be overloaded and taper away through its entire length. This is prevented by means of an ingenious arrangement of floating contact clamps which feed the current to that part of the positive carbon immediately behind the arc itself. The negative carbon, being metal coated and only 9 inches long (half the length of the positive), can carry the full current through its entire length. The current in the negative carbon is therefore conducted directly to the negative carbon clamp.

The positive carbon holder revolves upon the optical axis of the projector, and the crater is at

all times a perfect circle, presenting a very small but exceedingly brilliant surface head on to the condensing lenses. The negative and positive carbons are of the same diameter, but cored, and each has a different chemical composition in the core. As the current is fed into the high intensity carbons, a cup-shape crater is formed and a combination of gases is emitted and burned which develops the brilliant and splendid quality of the high intensity light.

Power's "G-E" high intensity arc lamp is absolutely automatic once the arc is struck, which means that the lamp embodies its own arc control, and this is also a radical advance in arc lamp construction. Once properly set in the lamphouse, the only adjustment required is the forward and backward movement of the entire lamp by means of which the size of the spot at the aperture is controlled.

Replacing carbons in the lamp is a very simple operation, as it is merely necessary to slip them into place and tighten screw in the carbon clamps. The terminals of the lamp are the same type as those used in Power's Type "E" lamp and there is an absolute assurance of a positive connection between the wire and the current carrying part of the lamp. There is no danger whatever of the wires burning loose from the terminals.

Power's "G-E" high intensity arc lamps can be supplied for three current rating as follows:

45 to 55 ampere lamp (50 to 55 volts, using 9 mm. positive carbon and 11/32nds of an inch negative carbon) admirably adapted to smaller theatres desiring the best possible

projection, but where conditions do not warrant the use of a 70 to 80 ampere lamp.

70 to 80 ampere lamp (55 to 60 volts, using 11 mm. positive carbon and $3/8$ths of an inch negative carbon) for most of the first-class moving picture theatres in the larger cities.

95 to 125 ampere lamp (60 to 70 volts, using 13.6 mm. positive carbon and 7/16ths of an inch negative carbon) for houses having an unusually long throw and an extremely large picture.

It is possible to advise as to the proper size lamp for any particular theatre, but we are always pleased to recommend the most suitable equipment if full details are submitted to us. Our engineering department will furnish blue prints and all other information necessary to insure the proper equipment.

To attempt to operate these lamps with a greater current variation than the maximum or minimum for the carbon sizes as shown by the above table would mean a great sacrifice in efficiency. It is therefore absolutely necessary to change the carbon diameters to secure satisfactory results.

In order to use the different size carbons it is necessary to change the positive and negative carbon clamps, the positive contact shoes and the positive and negative asbestos baffle plates. These parts can be easily changed, and with the exception of the parts mentioned, the balance of the lamp is identical for amperages from 45 to 125.

PROJECTION WITH MAZDA LAMPS

Optically, apparatus for motion picture projection with Mazda lamps comprises essentially a light source and condensing lens, a photographic print on a transparent film, a projection objective lens, and a screen, supplemented by a rotary shutter, an aperture plate and a mirrored reflector. These optical elements are shown in

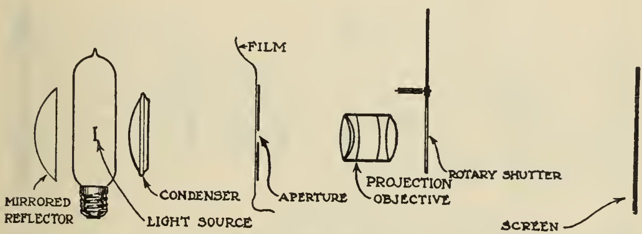


FIG. 345
Essential Optical Elements for Motion Picture Projection with Mazda Lamps

their respective positions in Fig. 345. A motion picture projector has, in addition, the mechanism for rapidly bringing successive pictures into position at the aperture and stopping them for a fraction of a second while they are projected as enlargements on the screen. These follow each other so rapidly (usually at the rate of about sixteen per second) that the eye does not distinguish individual pictures, but apparently beholds the motion in the scene photographed.

It is a well known fact that when rays of light from a luminous object pass through a pinhole, an image of the object appears when the beam is intercepted by a wall or screen. This is because light rays travel in straight lines and at a given point on the intercepting surface, light is received through a pinhole from only one part of the object. For a large, well illuminated image, such as is desired in the projection of motion pictures, an insufficient amount of light would be transmitted through the small pinhole. If a larger

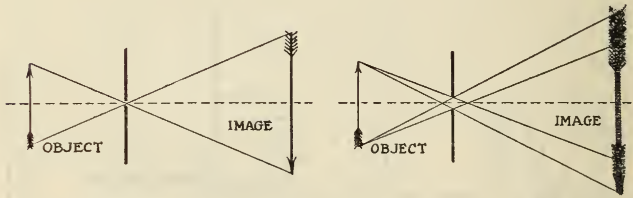


FIG. 346

Image Formation—Light from the luminous arrow at the left passing through the pinhole forms a sharp image at any distance; that transmitted by the larger hole produces a blurred image

hole were used in order to transmit more light, rays from many parts of the object would be received at a given point on the screen and hence no well defined image would result (See Fig. 346). The refractive properties of glass, that is, the power to bend the light rays and control their direction by the contour of the glass surfaces, are, however, utilized with the larger opening to direct the rays from each point on the object to a corresponding point on the screen. This operation, resulting in a defined image, is known as

focussing. The combination of glass elements used to accomplish focusing is known as a projection objective lens. Unlike the pinhole, such a lens produces an image only in one plane and its distance from the lens depends upon the contour of the glass surfaces, as well as upon the distance between the object and the lens (See Fig. 347).

Obviously, if an image is to appear as bright as possible the screen on which it is shown must

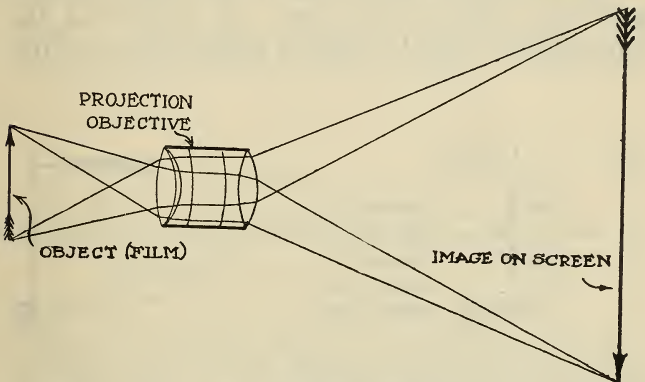


FIG. 347

The Projection Lens—Light reaching any part of the lens from a single point on the arrow is focused at only one point on the screen

have a surface which reflects a maximum amount of the incident light in the direction of the observers.

The area of the image on the screen in motion picture theaters is usually from 25,000 to 60,000 times that of the print on the film. Moreover, the projection lens absorbs some of the light, and nearly one-half of the remainder is absorbed by

the rotating shutter, with the result that the quantity of light passing through a unit area of the film, even when all of it is directed to the objective, must be from 70,000 to 170,000 times that received by each unit area of screen.

In order that a given point on the screen may be illuminated and an image formed, light source area must be disclosed on looking back from this point through the projection lens and a corresponding point in the film. In order that the illumination over the entire screen may be uni-

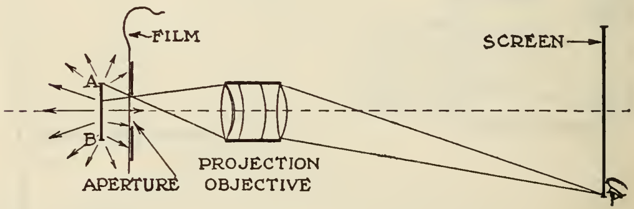


Fig. 348
Source Size Requirements—Source AB must be larger than the aperture to send light through a point at the edge of the aperture and through the full opening of the objective lens

form, equal areas of light source must be disclosed from each point on the screen. Inasmuch as the light rays cross, so that, for example, the upper part of the film is projected to the lower part of the screen, the apparent area of light source provided must be greater than that of the film by an amount depending upon its distance behind the film. Thus the source *AB* of Fig. 348, would be of sufficient size.

It happens that there are no sources which of themselves direct more than a small percentage of their light into the small angle included by the projection lens. Moreover, the heat radiated and conducted from the source in Fig. 349 would unduly raise the temperature of the film and its guides. Here again the refractive properties of glass may be employed to intercept the light emitted through a wider angle from a small source placed back from the aperture and to direct it through the film to the projection lens. By the proper design of the curvature of the faces

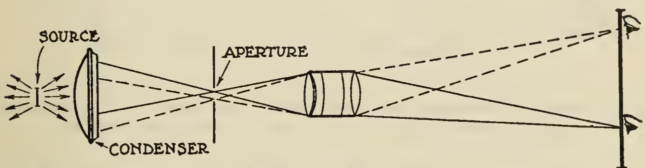


Fig. 349

Condenser Size Requirements—For uniform screen illumination, the size of the condensing lens must be such that equal areas of uniformly bright light source are seen on looking back from each point on the screen

of such a condensing lens it can be made of relatively large diameter with respect to the source dimensions and thus become both a large apparent source and a means of utilizing a large amount of the total light flux. The diameter of the condensing lens for various distances from the film is determined by the requirement that for uniform screen illumination equal areas of the lens must be visible through the optical system from all points on the screen (Fig. 349).

The converging beam from the condenser forms an image of the source at the point where the rays cross; as this is also at or near the narrowest part of the beam the aperture should be placed at this point in order that the greatest amount of light may pass through it, for with sources employed in practice the cross section of the converging beam from the condenser is, even at its narrowest part, usually equal to or greater

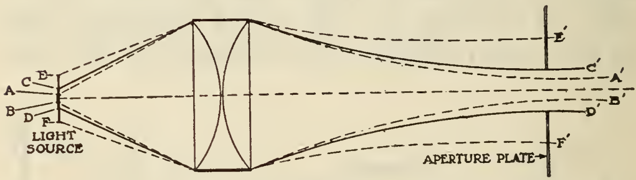


Fig. 350
For a given condensing lens, the size of the beam at the aperture plate is proportional to the size of the light source

than the area of the film. If the source is not of uniform brightness, the film placed at this position will not be evenly illuminated. Such a case is that of the incandescent lamp with the several filament coils separated by narrow spaces; however, if a spherical mirrored reflector is placed with its center of curvature approximately at the source it may be adjusted so that the images of the coils fall in the non-luminous spaces. The source then becomes in effect sufficiently uniform to permit the aperture to be placed only slightly nearer the condenser than the image position in order to produce satisfactory evenness of illumination for the film.

By the addition of the mirrored reflector a much larger proportion of the light from the source is utilized.

The aperture plate is a metal plate with an opening slightly smaller than a single picture of the film, and serves to limit the light beam to the single picture being projected.

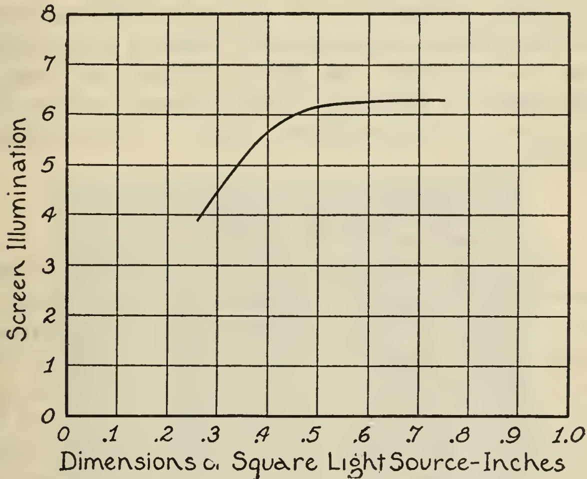


FIG. 351
Characteristic Relation Between Source Size and Screen Illumination for an Incandescent Lamp Motion Picture Projector

With the intermittent mechanism commonly employed for moving the film, the picture is in movement from one-fourth to one-fifth of the time. When sixteen pictures are projected per second, this means that approximately one hundredth of a second of movement is followed by five hundredths of a second with the picture in place. If

the light were allowed to reach the screen during the period of movement, flicker and blurring of the picture would result. Provision is, therefore, made for cutting off this light by means of a rotary shutter. If the light is cut off sixteen times per second, blurring can be obviated but flicker persists. Rotary shutters are, therefore, employed with two or three blades, so connected with the mechanism and of such width as to cut off the light from the picture while it is in motion and to interrupt the light similarly at regular intervals in between. With these higher frequencies of interruption, flicker is substantially eliminated.

LIGHT SOURCE

Since the film aperture and projection lens present openings of considerable area, there is no necessity for keeping the light source unduly small. The maximum size of source which can be employed effectively with a given optical system is dependent on the refracting powers of the condensing lens, the size of the aperture opening, the size of the projection lens, and the distance of the aperture from the condensing and projection lenses. A source of size *AB*, Fig. 350, projects a beam *A′B′* at the aperture, all of which passes through; the larger source *CD* will send a greater amount of light through the opening, but the source *EF* produces a beam *E′F′* at the aperture so large that but a small part passes through and the remainder of the light is wasted.

The curve of Fig. 351 shows the characteristic relation between source size and screen illumina-

tion of an optical system commonly used in motion picture projection. If the energy required for the source is in proportion to the source area, it is evident that each increment in screen illumination is obtained at an increasing cost for energy.

The light source in the Mazda lamp for motion picture projection consists of four parellel segments of coiled tungsten wire. The use of a heavy wire (high current, low voltage) permits more source surface to be placed within the useful source area than is possible when smaller wire

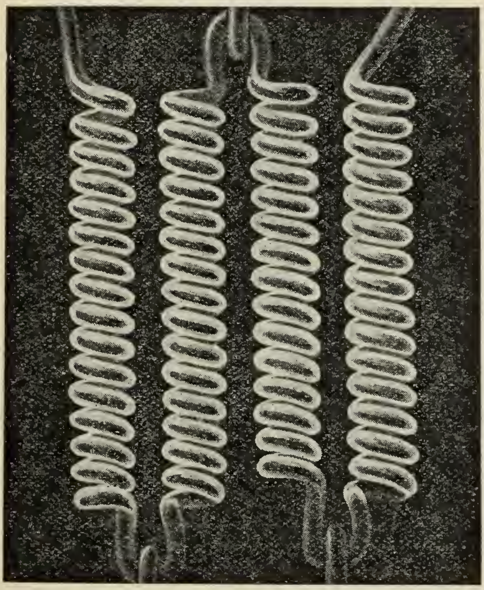


FIG. 352
Filament of the Mazda Lamp for Motion Picture Projection

sizes (lower current, higher voltage) are used. With the coils aligned in one plane at right angles to the optical axis (the line through the center of the optical units), the light can be most effectively controlled. The distribution curves of Figs. 353-354 show that the maximum candlepower and a large percentage of the total light can be directed toward the condenser and mirror, and the amount escaping at the sides kept small.

In order to prevent short-circuiting of the fila-

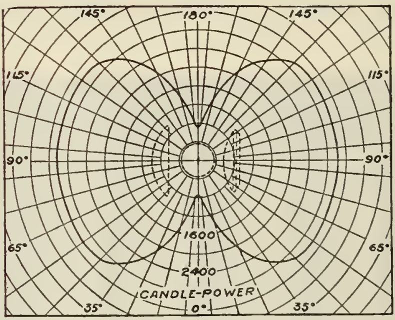


Fig. 353

Light Distribution from 900-Watt, 30-Ampere Mazda Lamp. A—Distribution in horizontal plane

ment coils they must be separated, and it is this separation that breaks up the uniformity of the light source and makes necessary the filling in of these spaces by the use of a mirrored reflector.

MIRRORED REFLECTOR

A mirrored-glass spherical reflector, Fig. 355, is placed behind the lamp so that the filament is

at the center curvature. It turns back about 80 to 85 per cent of the light striking it. The greater part of this light is brought to a focus in the plane of the filament as an inverted and reversed image of the filament. The mirror is moved just sufficiently to one side to permit the image of the filament to dovetail with the segments of the filament itself, as is shown in Fig. 356. With the mirror adjusted in this way, most

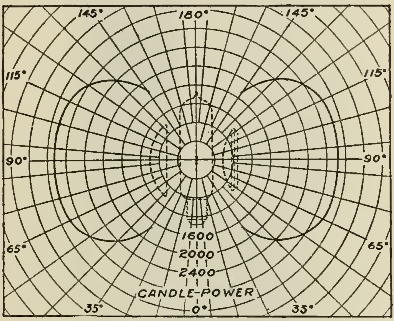


FIG. 354
B—Distribution in Vertical Plane

of the reflected light flux travels to the condenser in directions that permit the condensing lens to refract it with the beam from the filament itself.

Two important advantages result: (1) the screen illumination is increased from 65 to 75 per cent, and (2) the source becomes in effect a solid luminous rectangle, and evenness of screen illumination is thereby obtained.

In order that a maximum percentage of the light may be utilized, the plane angle subtended

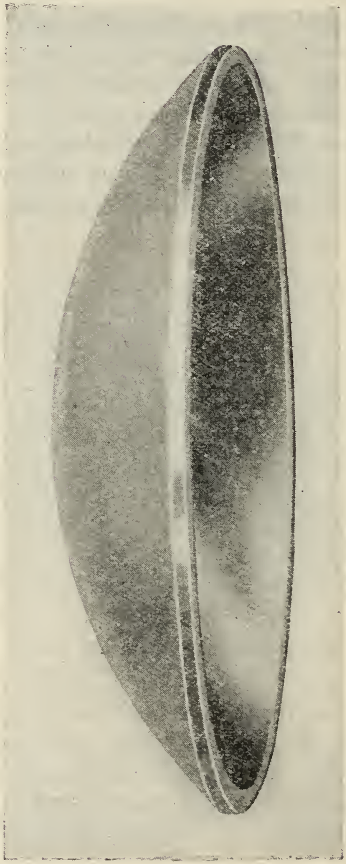


FIG. 355

Mirrored Glass Spherical Reflector for Use with 900-Watt Mazda Lamps. Diameter, 5¼ inches; outside radius of curvature, 3⅜ inches

by the mirror should be from 15 to 20 per cent greater than that subtended by the condenser. The diameter required to intercept this angle is relatively small if the mirror is placed close to the lamp, but the mirror is then subjected to considerable heating from the lamp with consequent danger of rapid deterioration. With mirrors of less curvature and correspondingly increased diameter, not only is the surface farther from the hot lamp but there is greater area provided for dissipating the radiant heat which it absorbs.

CONDENSING LENS

As was stated above, the condensing lens is a device for intercepting a large solid angle of the light emitted by a lamp placed some distance from the film and redirecting it so as to send it through the film to the projecting lens and screen. It is evident that the larger the diameter of a condensing lens of a given refracting power, the more light it will pick up. (When parallel rays of light are intercepted by a lens, they are so bent as to pass substantially through a point some distance beyond the lens, which point is called the focus. The shorter the distance from the center of the lens to the focus, i. e., the shorter the focal length, the greater is said to be the refracting power of the lens.) But with increased diameter the thickness also becomes greater, and very thick lenses cause spherical aberration, that is, they bend these light rays near the edge more than those through the central part. A moderate amount of spherical aberration is an advantage

in that it produces a smaller beam at the aperture position, but if it is so marked that a considerable part of the light is directed outside the projection lens, the gain in light intercepted by the greater diameter is soon lost. To prevent excessive aberration two or thre thin lenses are used in com-

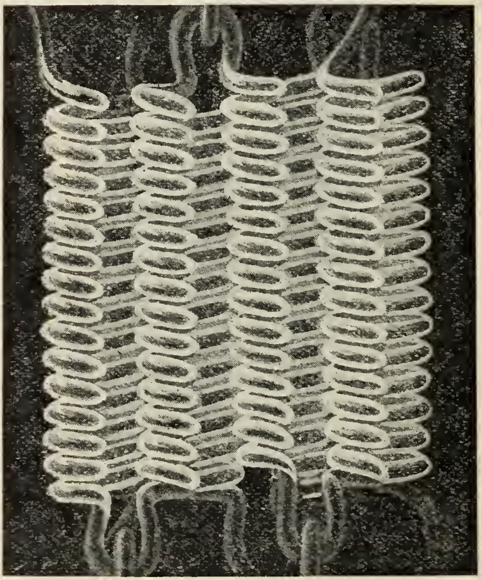


FIG. 356
The Reflected Image of Filament Segments Intermeshed with the Coils

bination instead of one thick lens. Another method is to cut away some of the glass of a thick lens as in the modified Fresnel lens shown in cross-section in Fig. 360. Here in a single piece of

glass are really five relatively thin circular prisms surrounding a double convex lens. The Fresnel, or prismatic, lens has two marked advantages ever spheric combinations of similar refracting power:

First, for a given degree of spherical aberration, it can be made to intercept the light through a larger solid angle;

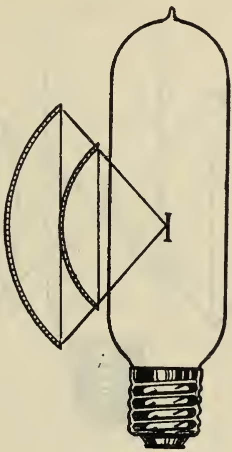


FIG. 357

Mirror Size—To intercept the same amount of light flux the diameter of the mirror must increase proportionately with the radius of curvature

Second, the contour of the several prism surfaces can be designed so that the light from each ring is directed to a different part of the film. Thus the light source is focused at different distances from the condenser,

with the result that at the aperture no well-defined source image appears, and uniform illumination of the film is obtained.

On the other hand, the percentage of light lost is comparatively high with this lens, since the rays that strike the risers of the prisms are reflected at angles where they cannot be used. This loss, together with those of absorption and reflec-

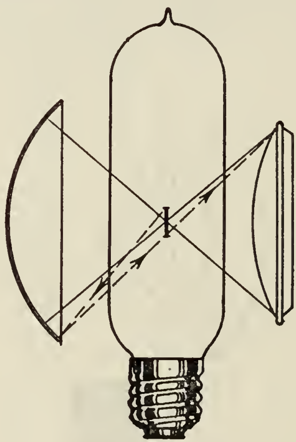


FIG. 358

Mirror Size—The condenser will redirect light from a reflector which intercepts a larger angle of light than does the condenser

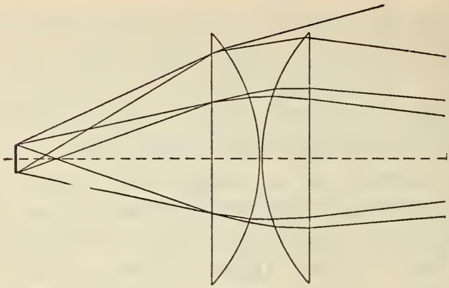
tion from the surfaces, is of the order of 30 per cent.

A third way to reduce aberration and thus to make feasible a lens intercepting a larger angle of light is the modification of the lens surface to other than spherical form, using curvatures designed to produce a beam of uniform class sec-

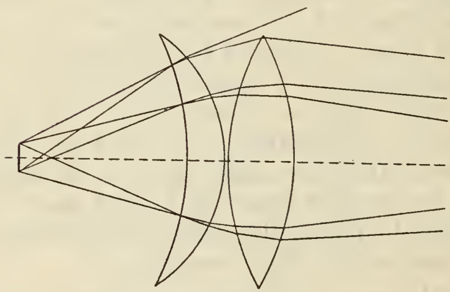
tion at the film, with a maximum percentage of the light directed to the projection lens. The limitation preventing the application of this method has been the lack of a commercially practical method of grinding the surfaces.

Each element of a condensing lens of other than the prismatic type will cause a loss through absorption and reflection of approximately 10 per cent of the incident light. Most of this is due to reflection at the surfaces, which varies with the angle of incidence. The loss by absorption is of the order of 3 to 6 per cent per inch of thickness. In a well designed three-element combination consisting of a meniscus and two plano-convex units there is a loss of about 30 per cent; but where the elements are of the same diameter, as is more often the case, there is an additional loss due to the fact that the second lens does not intercept all of the diverging rays issuing from the one nearest the light source.

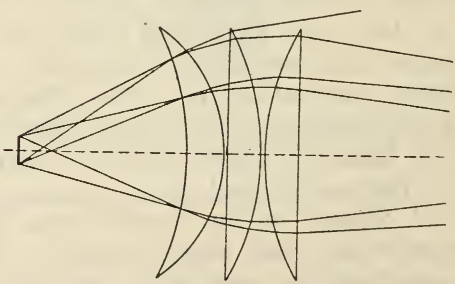
As light passes through a lens the rays of different colors are bent through slightly different angles, so that from any small area of the lens the refracted light spreads into diverging rays of the different spectral colors. This phenomenon is known as chromatic aberration. Except at the edge of the beam, or where there is a sharp contrast with the background, as in the case of the outlines of objects in the image, these several colors superimpose and blend together. A projection lens must be essentially free from chromatic aberration; but in the case of condensing lenses, the projection of these colors to the screen can be avoided by intercepting the edge of the



A



B



C

FIG. 359
Types of Condensing Lenses Applicable for Both Motion Picture and Lantern Slide Projection. A—Double Plano-Convex; B—Meniscus—Bi-Convex; C—Meniscus—Double Plano-Convex

beam and using a lens of such design that the lamp filament is not focused as an image at the aperture.

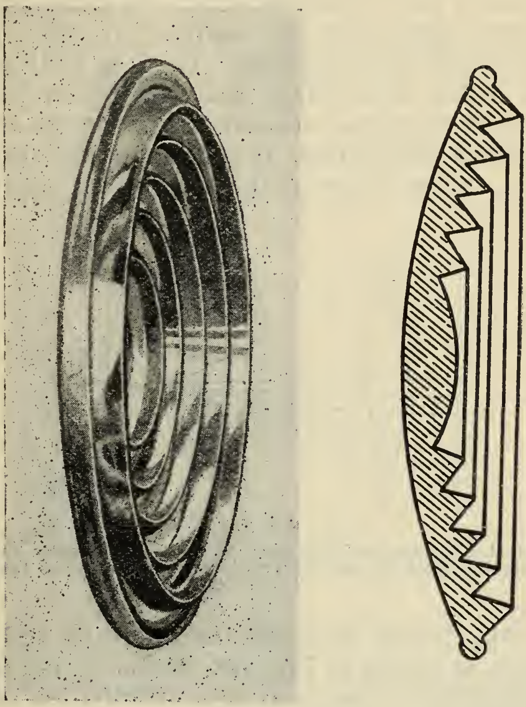


FIG. 360

Prismatic Condensing Lens for Motion Picture Projection with Mazda Lamps

PRISMATIC CONDENSER

The prismatic condensing lens is recommended for use with Mazda lamps. As designed for this service, it has a diameter of 4 7/16 inches and intercepts light from the source through a plane angle of 78 to 80 degrees. Used in conjunction with a No. 2, or large size, projection lens, it insures a maximum amount of light on the screen, uniformly distributed. It is designed for spacings of 2½ inches between the source and condenser

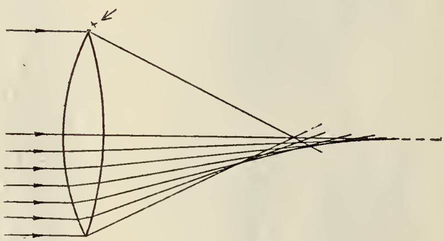


FIG. 361

Spherical Aberration—That part of a thick lens near the edge refracts the light through a greater angle than does that near the center

and 6½ inches between the aperture and condenser, as shown in Fig. 362. Either lower screen illumination or less even light distribution results when the source-condenser distance is changed; the condenser-aperature spacing may, however, be varied ½ inch either way from the recommended spacing without seriously impairing the results. Moreover, the required spacings need not be altered for different throws or sizes of picture. A distinct advantage of the prismatic

condenser is that slight displacement of the mirrored reflector does not result in objectionable non-uniformity of screen illumination. The spacings are comparatively short, permitting compact design of the projector.

A limitation of the prismatic condenser is that it is not suitable for slide projection since the

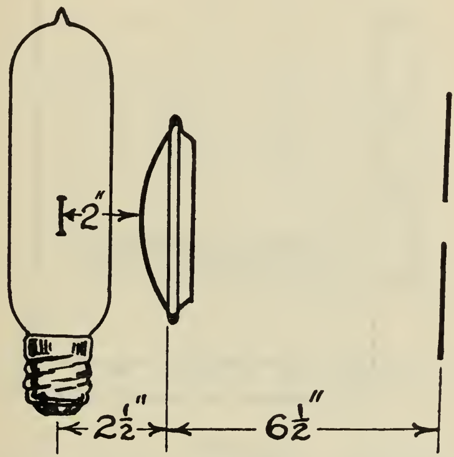


Fig. 362

risers of the prisms deflect the light so much that dark rings appear in the beam near the condenser where the slide would have to be placed to be covered by the beam, although they are filled in by the crossing of the rays farther out in the beam. For this service either a separate projection lantern must be used, which is the best practice, or condensing lenses suitable for slide

projection must be provided in addition to the prismatic condenser.

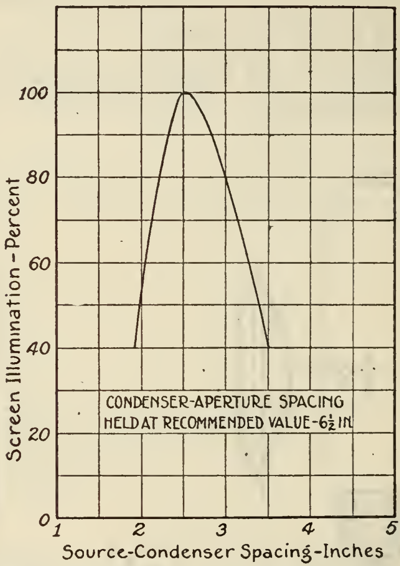


FIG. 363
Variation of Screen Illumination with Source-Condenser Spacing, for Prismatic Condenser

PLANO-CONVEX CONDENSER COMBINATION

The beam of light from two plano-convex lenses is very uniform near the lens and this combination is therefore suitable for slide projection. Where it is used both for this purpose and the projection of the film, the usual practice is to have the slide holder fixed in front of the con-

densers, where it intercepts 15 per cent or more of the light which would otherwise pass through the film aperture. To avoid this unnecessary loss provision should be made for raising or lowering the slide holder away from the condensers, or moving it to one side during the projection of motion picture film.

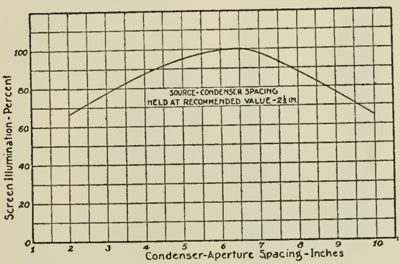


FIG. 364
Variation of Screen Illumination with Condenser-Aperture Spacing, for Prismatic Condenser

The plano-convex condenser produces a well defined image of the lamp filament slightly beyond the smallest cross section of the beam, and there is a resultant unevenness of illumination at the narrowest part, where the aperture must be placed for best efficiency. Its success in motion picture projection is therefore dependent on the extent to which the source can be made uniform by filling in the spaces between the coils with coil images from the mirrored reflector. If the reflector is carefully set by precision methods applicable in laboratory rather than in theater

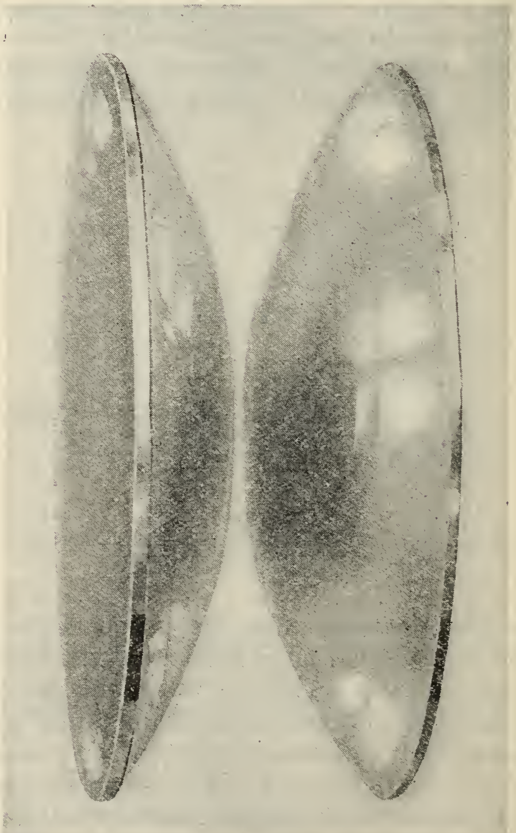


FIG. 365
Plano-Convex Condensing Lens Combination

practice, and certain source-condenser and condenser-aperture spacings are employed, it is possible to obtain with plano-convex condensers screen illumination values as high as those ob-

TABLE 1—SPACING DISTANCES FOR PLANO-CONVEX CONDENSERS FOR MAXIMUM SCREEN ILLUMINATION

Applicable only with precise adjustments of the mirrored reflector

Projection Objective Lens		Condenser Focal Lengths	Spacings	
Size	Equivalent Focus		Source-Condenser	Condenser-Aperture
			(A)	(B)
No. 1......	3½″ to 5½″	6½″ & 7½″	4″	8″
No. 1......	5½″ to 7½″	6½″ & 7½″	3¾″	9″
No. 2......	5½″ to 7½″	6½″ & 7½″	3¾″	9″
No. 2*.....	5½″ to 7½″	6½″ & 6½″	3½″	8″

Distance between plano-convex lenses 1/16 inch.

*Useful for motion pictures only since screen illumination would fade off at edges of lantern slides.

tained with the prismatic condenser, with a tolerable uniformity of screen illumination. But a slight deviation from this exact adjustment of the mirrored reflector results in marked vertical streaks on the screen and the projected picture is unsatisfactory. Table 1 shows spacing distances for the plano-convex condensers which are at present of interest only for laboratory applica-

tion. They do not hold true with the method of reflector adjustment ordinarily employed in theaters, namely, that of observing pinhole images of the filament on the fire shutter. With this method of reflector adjustment, the lamp-condenser or condenser-aperture spacing must be materially decreased, but such settings produce a loss in the light projected of the order of 30 to 50 per cent.

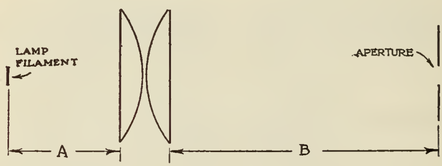


FIG. 366
Spacing Designations for Plano-Convex Condensing Lens (As used in Table 1)

In view of the practical difficulties of obtaining the mirrored reflector adjustment for maximum screen illumination with the plano-convex condenser combination, its use with Mazda lamps is not recommended for theater projection.

APERTURE

The standard aperture is a rectangular opening 0.6795 inches high and 0.906 inches wide. The aperture plate across which the film moves must, for best efficiency, be located where as much as possible of the converging beam from the condensing lens will pass through the opening and

at the same time be uniformly distributed over this area. In practice a light beam larger in diameter than the diagonal of the aperture opening must be used since the light near the edge of the beam is of somewhat lower intensity and shows color due to chromatic aberration from the condensing lens, and this part, constituting from 40 to 65 per cent, must therefore be intercepted. If the aperture plate were located at position *a* of Fig. 367 an unnecessary amount of the light would be wasted; if place in position *b*, the unevenness of distribution in the beam would become notice-

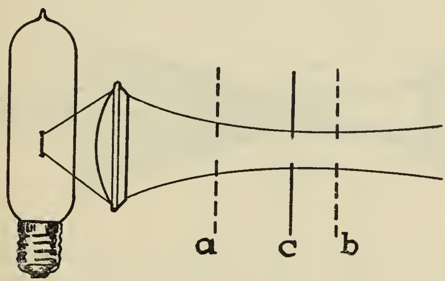


FIG. 367

Placing the Aperture—At position *a* considerable light is wasted; at *b* the beam is not uniform and a small part of the light is wasted; position *c* is the correct one for the prismatic condenser

able. In position *c* the aperture is correctly placed for the condensing lens shown; the light passing through it is uniform throughout the open area; only enough is intercepted to leave the projected beam practically uniform in cross section.

PROJECTION OBJECTIVE LENS

From Fig. 347 it will be seen that the projection lens consists of three elements, one of which is a cemented doublet. By combining suitable optical glasses in elements of proper thickness, surface curvature, and spacing the units can be given the following characteristics:

1. Freedom from spherical aberration, providing good definition;

2. Flatness of field, which produces equally sharp images over the entire screen picture;

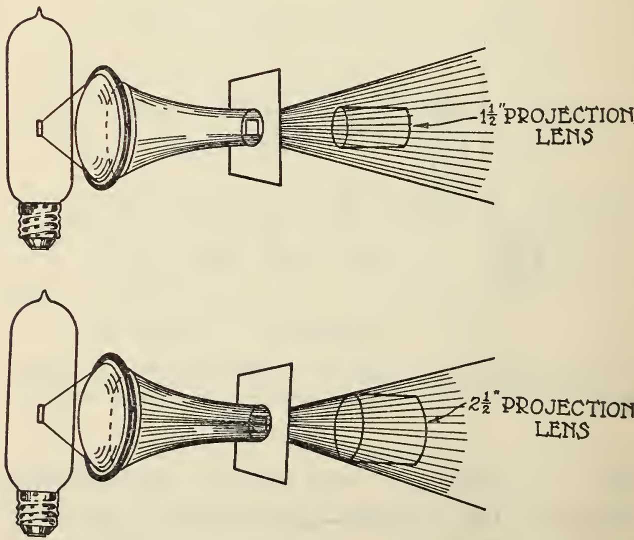


FIG. 368

The cross-section of the beam at the position of the objective lens is so large that the No. 2 objective lens utilizes twice as much light as does the No. 1 lens

3. Freedom from chromatic aberration, eliminating colored fringes on the screen image;

4. Large diameter and free aperture, giving high screen illumination.

The commercial objective lenses are obtainable in two sizes, the "quarter" size or No. 1 lens of about 1½-inch free aperture, and the "half size" or No. 2 lens of about 2½-inch free aperture.

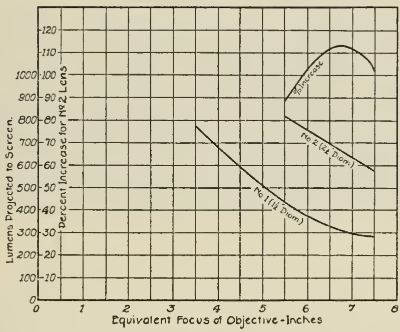


FIG. 369

Light Flux Projected to Screen When the 900-Watt, 30-Ampere Mazda Lamp and the Prismatic Condenser Are Used with the No. 1 and No. 2 Projection Lenses of Various Focal Lengths. Beam Unobstructed by Rotary Shutter or Film

The first three characteristics are most easily obtained in the No. 1 lenses and the longer focal lengths. But as is shown in Fig. 367, the beam diverges rapidly after passing through the aperture, and to obtain maximum screen illumination the lens of larger diameter should be used. The curves of Fig. 368 show the relative amounts of light projected to the screen with objectives of the two sizes and the prismatic condenser of 4 7/16

inch diameter. In general, twice as much light is projected with the larger lens. Until recently the No. 2 lenses were not obtainable with the better corrections of the small size, but with increased skill in design and manufacture high grade No. 2 lenses have recently been made available by the principal manufacturers and these have essentially the same charactertistics as the best No. 1 lenses. *These higher grade No. 2 projection lenses should be used for projection with* MAZDA *lamps.* They are at present obtainable for all focal lengths from 5¾ inches upward. These higher grade objectives are also available in the No. 1 sizes for the shorter focal lengths.

The focal length of the objective lens determines the picture size for a given throw. With

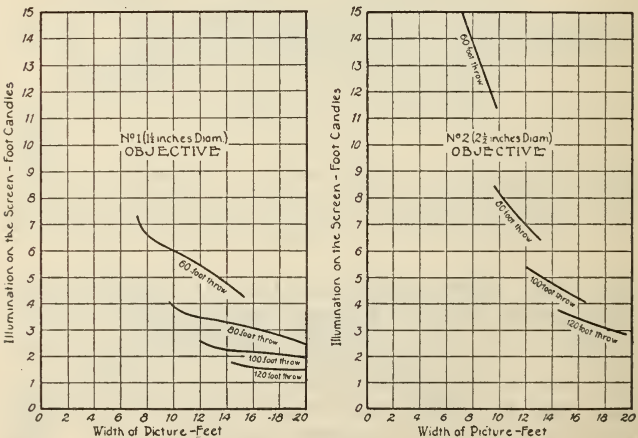


FIG. 370

Variation of Screen Illumination with Picture Size for 900-Watt Mazda Lamp and Prismatic Condenser. Beam Unobstructed by Rotary Shutter or Film

the width of the picture selected, the focal length of the required objective lens is given with sufficient accuracy for practically all purposes by the approximate formula:

$$\text{Equivalent focus (in.)} = \frac{\text{Throw (ft.)} \times 0.906}{\text{Picture Width (ft.)}}$$

The throw is measured from the center of the objective to the screen; the formula applies for an aperture of standard size.

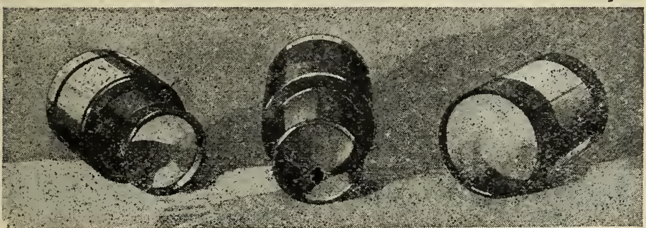


FIG. 371

High Grade No. 2 Objective Lenses

For a given throw, increase in the picture area decreases the average screen illumination but not proportionately, since a larger amount of light is transmitted by projection lenses of shorter focal length. The data of Fig. 370 show the effect of change in picture width on the screen illumination for a 30-ampere Mazda lamp and the prismatic condensing lens.

To determine a desirable size of picture it is necessary to give consideration to maximum and minimum limitations determined by the angle which the picture subtends at the eyes of those in the front seats and those farthest away from the

screen. Observations indicate that under usual conditions the picture appears too small if its width subtends an angle of less than about nine degrees, and, on the other hand, it cannot be viewed with comfort by those at the front of the house if it subtends an angle of more than about 45 degrees.

ROTARY SHUTTER

Figure 372 shows a typical rotary shutter which is placed in front of the objective lens and

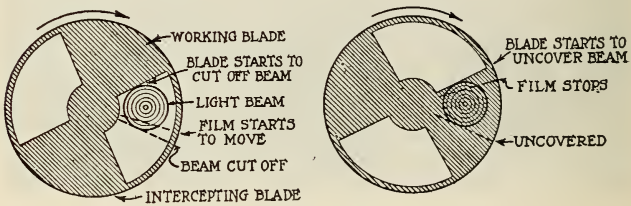


FIG. 372

With skillful setting, the width of the working blade of the rotary shutter can be reduced so that the film starts to move before the beam is entirely covered, and the blade starts to uncover before the film movement has stopped

adjusted so as to cut off the light from the screen during the period that the film is in motion. The blade is made of such a width that the film starts to move before the light beam is entirely cut off and the blade also starts to uncover the beam before the film is stopped. The periods during which the stationary film is being covered and uncovered is thus reduced to a minimum; the small amount of light reaching the screen during the short period of exposed film movement is not noticed.

Interruption of the light 16 times per second would result in pronounced flicker, therefore one or two blades are provided in addition to the working or "travel" blade that cuts off the light during the film movement. These intercepting or "flicker" blades can by skillful design be made narrower than the working blade and thus the loss of light may be reduced. The number of

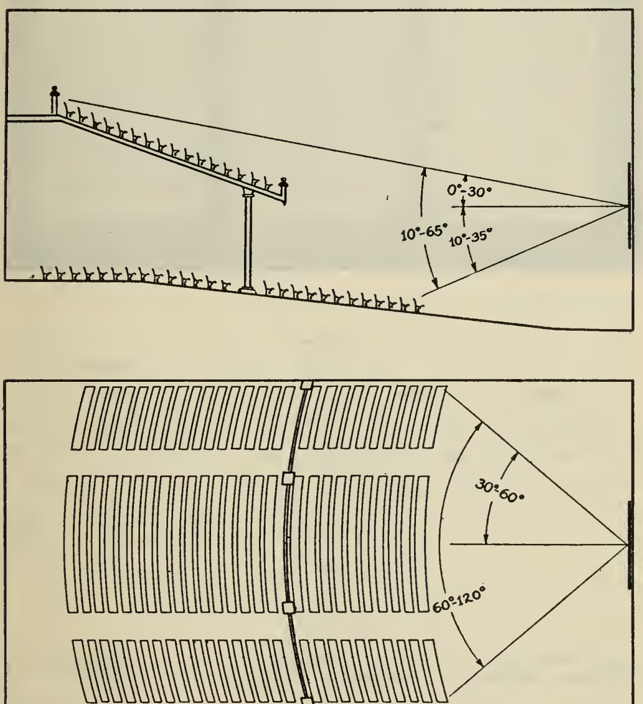
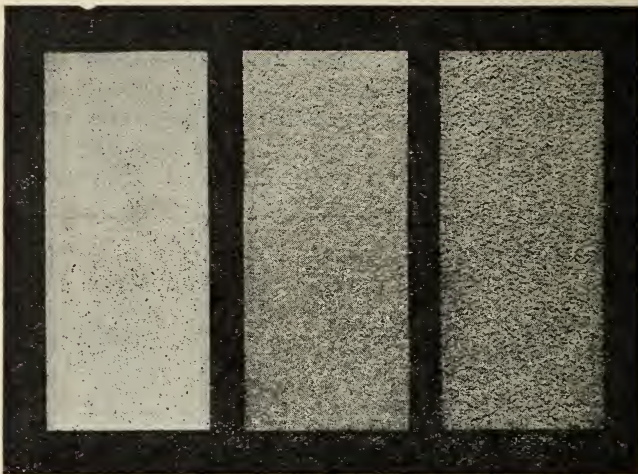


FIG. 373

Representative Angles Within Which the Screen Must Direct Light to the Observers



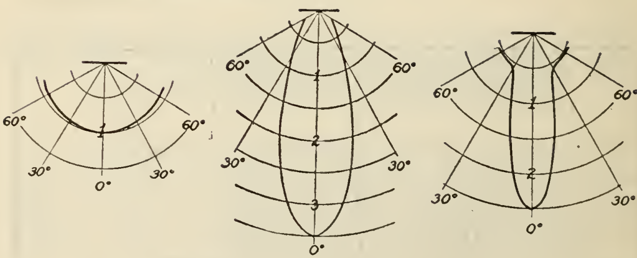


FIG. 374

A—White Diffusing Surface

B—Semi-Mat Metallized Surface

C—Beaded Surface

Three Representative Screen Surfaces and Brightness Distributions When Equal Quantities of Light Are Directed in Beams Normal to the Surface

blades required depends on the brightness of the screen. At ordinary intensities of screen illumination a two-blade shutter interrupting the light 32 times per second at normal projection speed eliminates flicker; but with a very bright screen a three-blade shutter interrupting the light 48 times per second is required. The two-blade shutter can in most cases be employed with Mazda lamps.

It is of interest to note that due to the heat, storing capacity of the heavy filament wire used for MAZDA motion picture lamps, the illumination produced by the lamps does not show a cyclic variation on alternating current; the illumination is steady even on 25-cycle circuits and the choice of shutters is therefore not affected by any possible stroboscopic effects.

Since the angular width of the working blade is determined by the ratio of time of film movement to the stationary period, the shutter transmission varies with the intermittent ratio as well as with the size of the objective lens, or the width of the light beam. For best efficiency the shutter should be placed where the beam diameter is smallest. With the condenser spacings used in MAZDA lamp systems, the light beam emerging from the objective lens is smallest in diameter at the lens, so that the narrowest blades can be used when the shutter is placed as close as practicable to the lens holder.

The rotary shutters ordinarily employed have a transmission of about 50 to 55 per cent for the two-blade type and from 40 to 45 per cent for the three-blade type. Successful designs of the former are in use having a transmission of 60 per cent for a No. 2 lens. Skillful narrowing of the blades and their perforation with small holes are

methods employed to obtain the higher transmission values. If carried too far with the working blade a "travel" ghost is noticeable on the film titles. Whatever additional light is obtained by such modification of the intercepting blade without having flicker appear on the screen is probably a clear gain, but any light received on the screen through the moving film is a detriment rather than an advantage. A third and interesting means of reducing shutter losses is the use of two disks rotating in opposite directions; the periods of covering and uncovering the beam are thus

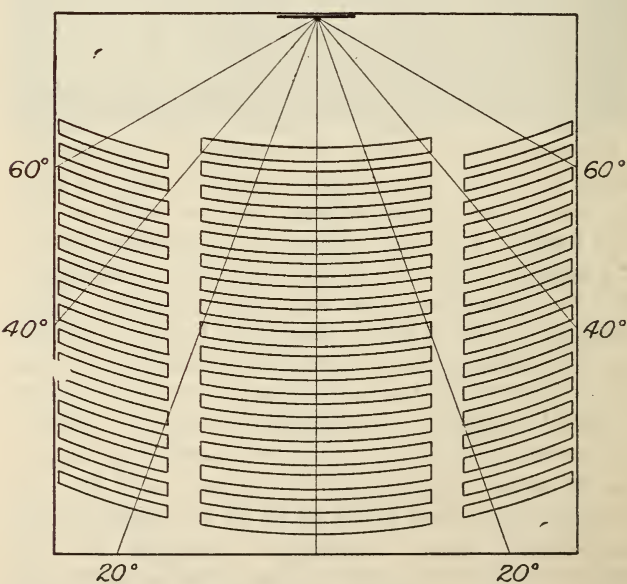


FIG. 375
In a wide theater the diffusing screen appears practically equally bright from all of the seats

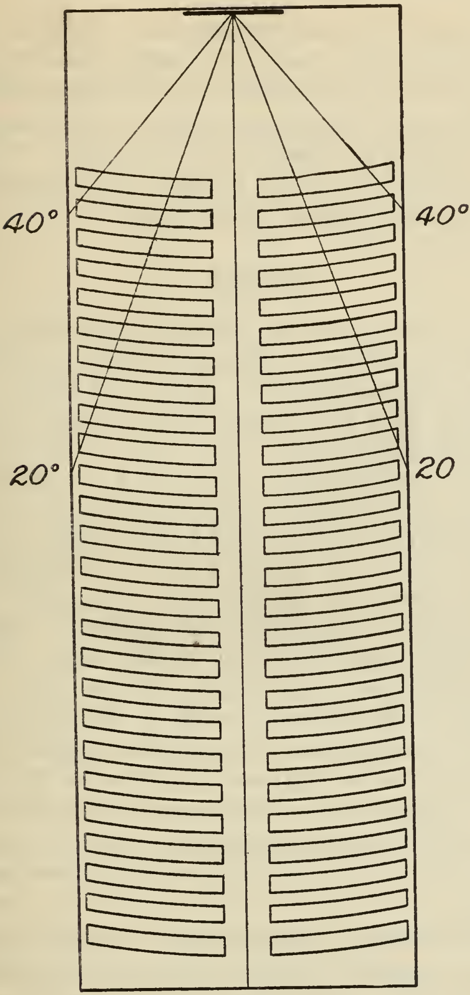


FIG. 376

Eighty-seven per cent of the seats in this narrow theater fall within 20 degrees of a normal to the screen. The average brightness of a semi-mat metallized screen surface as viewed from this audience will be 2¾ times that obtained with a diffusing screen

reduced approximately one-third, but such shutters require very careful setting and special attention to the mechanism for their operation.

It should be noted that whatever data are given in this bulletin showing the transmission of light through various optical systems they apply for the beam unobstructed by a shutter.

Screen

The last step in the efficient projection of a satisfactory picture is the provision of a screen which will most effectively direct the light to the audience so that the images there formed may be seen without effort from every seat. It is desirable that the screen surface have a high reflection factor, but it is even more important that it direct a maximum part of the light back within the solid angle in which are included all of the seats, and that the light be so distributed within this angle that the screen will appear, as nearly as possible, equally illuminated from all of the seats. In the wide theaters the outer seats in front often make an angle of 60 degrees with a normal to the screen; in the narrower houses the angle is sometimes as low as 30 degrees, as shown in Fig. 373; in the vertical plane the lowest front seats are occasionally as much as 35 degrees below a normal to the screen, and the highest seats 30 degrees above it.

The distribution of light from a screen surface can be controlled by choice of material, its finish, texture, and configuration. The screens so far available meet the requirements fairly well in many theatres but somewhat imperfectly in

others; that is, there is not so great a diversity of light reflecting characteristics as would be desirable for greatest efficiency in each case. The three principal types in use are shown in Fig. 374, together with curves indicating the relative brightness as viewed from the different angles when a unit quantity of light is directed in a beam normal to the screen. Thus at right angles to the surface, the mat diffusing screen has a brightness of 1.0 unit and this is maintained at 0.94 units at 30 degrees from the normal, and falls only to 0.9 at 60 degrees; the semi-mat metallic surface, on the other hand, has a brightness of 3.5 units at right angles to the screen, but at 30 degrees it is reduced to 0.8 units, and at 60 degrees it is only 0.25 units. It should be noted that the areas included within the several curves are not at all proportional to the amount of light reflected from each screen.

Since with the mat diffusing surface shown in Fig. 374, the maximum brightness is well maintained at all angles, a screen of this characteristic is especially adapted to very wide theatres, such as that shown in Fig. 375. Although the outside front seats lie 65 degrees from the normal, the brightness in their direction is about 90 per cent and the average brightness for all of the seats is 96 per cent of the maximum. In general, the diffusing surfaces should be used where a considerable portion of the seats lie more than 40 degrees from the normal to the screen.

The smooth metallized surface, Fig. 374B, is especially applicable for the narrower houses, such as the one shown in Fig. 376. There the front

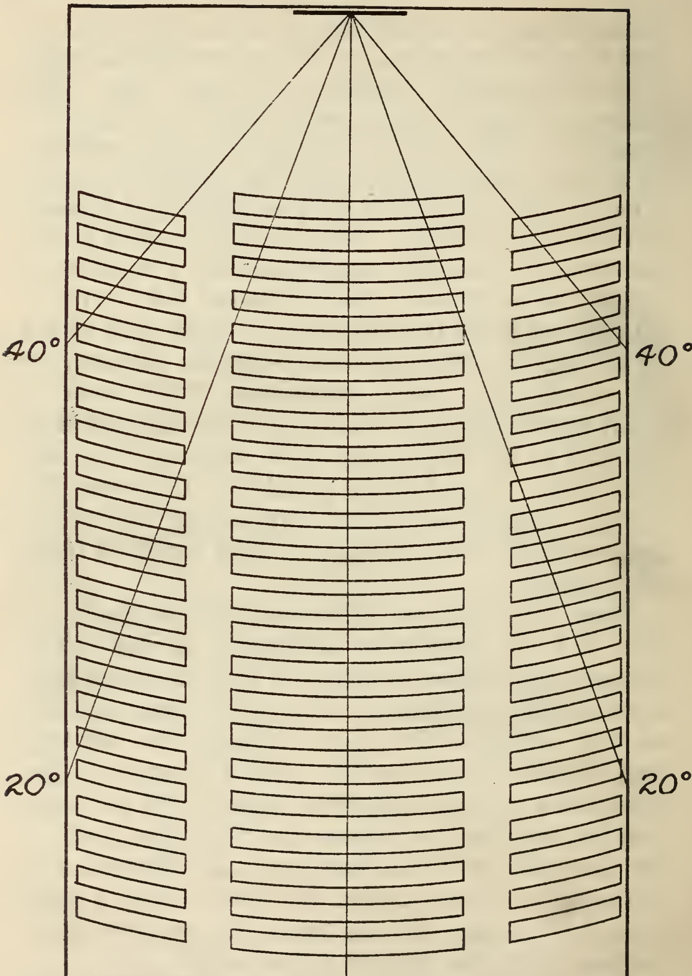


FIG. 377
Medium Width Theater—The metallized surface screen has an average brightness as seen from 88 per cent of the seats about 2½ times that for a diffusing surface

end seats are about 40 degrees from the normal, but 97 per cent are within 30 degrees, at which angle the brightness is still 0.8 units, and 87 per cent are within 20 degrees, where the value is 1.6 units. The average screen brightness as viewed from the seats of this theatre will, therefore, with this type of screen be 2¾ times what it would be with the diffusing type. The more usual case is that of the theatre of medium width, shown in Fig. 377, where the end front seats make an angle of 50 degrees with the normal. But even here 88 per cent of the seats fall within 30 degrees of the normal, and all of these seats receive more light from screen *B* than from screen *A*, in fact about 2½ times as much for the average. For the remaining 12 per cent the screen appears only about one-half as bright as would one of the diffusing type.

The beaded surface, Fig. 374C, has a somewhat lower maximum brightness than the semi-mat metallic surface, but higher values at angles of about 35 degrees and beyond. The brightness of the diffusing screen, on the other hand, is somewhat higher at all angles beyond 20 degrees. The beaded surface finds its best application in theatres of medium width. In the house shown in Fig. 377, 71 per cent of the seats fall within 20 degrees of the normal and these will receive about twice the brightness that would be directed from screen *A*, but in the directions of the remaining 29 per cent the average brightness will be only 60 per cent as much as from *A*. An important consideration is the fact that the bead screen can be cleaned by washing and hence it is likely that

A—White
Diffusing
Surface

.B—Semi-Mat
Metallized
Surface

C—Beaded
Surface

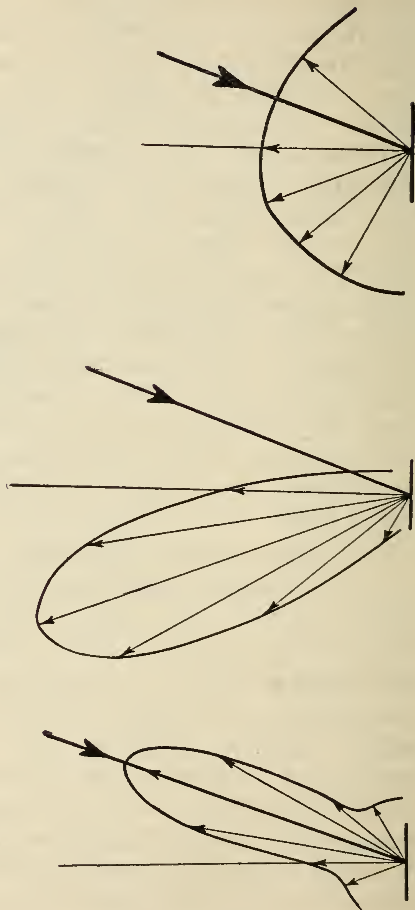


FIG. 378

Reflection Characteristics of the Three Types of Screen Surfaces When the Beam from the Projector Is Directed to Them at an Angle

its reflecting power will be maintained at more nearly its full value than will be the case with surfaces requiring repainting or refinishing for their restoration from accumulations of dirt, which in service reduce the reflection factor very greatly.

In the foregoing, reference has been made only to the light distribution in the horizontal plane, but since the seats are at various elevations the brightness distribution in the vertical plane must also be considered. This is especially important

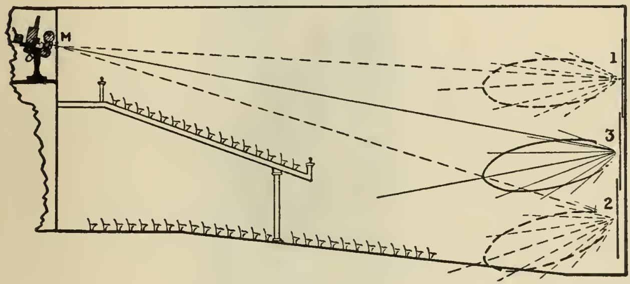


FIG. 379

Apparent Screen Brightness as Affected by Height of Mounting: Position 1 favors the high balcony seats; position 2 wastes most of the light; position 3 is probably most effective for this house

in view of the fact that the three types of screen surfaces act differently in reflecting the light received at an angle with a normal to the surface. From the metallic surface screens, for example, the reflection is to a considerable extent specular, as from a mirror; that is, the general direction of the reflected beam makes an angle with the normal equal to the angle of incidence, as in Fig. 378B. A metallic surface screen in the theatre shown in

elevation in Fig. 379 would give an unsatisfactory distribution of light if placed in position *1*. Position *2* would favor the front seats at the expense of those in the rear and balcony, but position *3* would give a well balanced distribution of the

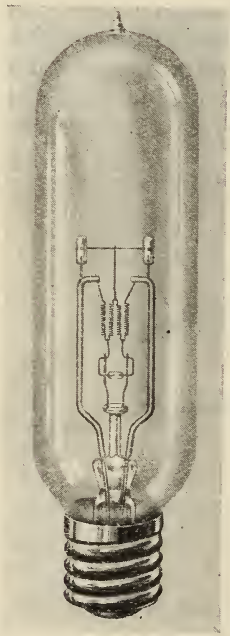


FIG. 380

900-Watt, 30-Ampere Mazda Motion Picture Lamp. The 600-watt, 20-ampere lamp is similar in appearance

light. Tilting the screen backward at the top assists in raising the angle of maximum brightness in case the screen cannot be mounted at the desired height. The comfort of the audience must

also be considered in determining the best screen position; if it is too high, those near the front cannot be at ease in viewing the picture. The bead screen reflects a maximum brightness in the direction of the projector, as shown in Fig. 378C, because the specular part of the reflection is largely from that part of the glass bead surfaces normal to the beam. Obviously this screen finds its best application in theatres where the seats are not far below the projected beam. The direction from which the incident light is received has little effect on the distribution from the diffusing screen, as shown by Fig. 378A.

The screen brightness necessary to produce the best pictures varies with the reflecting characteristics and texture of the screen surface employed. The most satisfactory brightness appears to be materially lower with a diffusing type of screen than with those giving a pronounced directional distribution. This tends to make the results with the diffusing screen relatively better than would be indicated from the respective brightness values given in the above discussion. An additional factor to be taken into consideration is that a lower order of brightness suffices for the seats nearer the screen than for those farthest away. Although for a given light source the screen brightness decreases somewhat with the larger pictures, as may be seen from the illumination values of Fig. 370, there is a compensating factor in that the brightness required for a good picture decreases as the size is increased.

The proportions of the theatre, the range of seat elevations and the position of the projection

room with reference to the stage must therefore all receive careful consideration in the selection and mounting of the screen. The relative size of the screen images is in direct proportion to their distances from the projector. When the light is projected at a considerable vertical angle from the normal to the screen, the picture will be noticeably wider at the bottom than at the top. The distortion of the picture as well as the distribution of screen brightness to all parts of the audience accordingly imposes limits in the design of a theatre. The architectural treatment of a new theatre can readily be adapted to produce conditions for favorable screen results. Placing the projection room lower than has been common practice even in the newer theatres will assist in the projection of good motion pictures.

ILLUMINATION OF THE THEATRE AUDITORIUM

The illumination of the auditorium during the projection of the picture vitally affects the required screen brightness, and the selection and placing of the lighting equipment must therefore be treated as a phase of the projection problem. There must be sufficient light to create an agreeable atmosphere and to permit the theatre patrons to find or leave their seats safely during the projection of pictures, yet the eye should encounter no very bright areas and the light directed to the screen from fixtures or vertical surfaces facing the stage should be kept at a minimum, in order that contrasts in the screen picture will not be

materially affected. If but one per cent of the screen brightness is contributed from sources other than the projector, the screen illumination must be increased by 30 to 40 per cent in order to produce as satisfactory results as though no extraneous light reached the screen. The other surfaces at the front of the house should, however, receive some illumination so that excessive contrasts of brightness may be avoided. The theatre exterior, lobby, and foyer are usually brilliantly lighted in order to appear cheerful and attractive. However, the eyes of the patrons are thereby adapted to this level and it requires time for their adjustment to the lower level desirable in the auditorium. By lighting the rear of the auditorium to a moderate intensity and gradually decreasing this to the front, the eyes are given an opportunity to adapt themselves as one passes down the aisle, and at the same time the illumination reaching the screen is kept at a minimum. The use of indirect lighting equipments, or units with deep reflectors, shades, or shields, and of auxiliary aisle lighting, obviates the interference with vision caused by bright surfaces near the field of view. Frequently beams or other architectural features may be employed to prevent the direct light from reaching the stage and to shield the eyes of the audience. The brightly lighted music sheets of the orchestra may cause annoyance when in the line of vision, and they sometimes reflect a considerable amount of light to the screen. Judicious placing and masking of the music racks will frequently improve these conditions.

MAZDA lamps for theatre motion picture projection are available in two sizes, rated at 900 watts, 30 amperes, and 600 watts, 20 amperes, respectively; the voltage of each size is within the range of 28 to 32 volts.

TABLE II.—MAZDA LAMPS FOR MOTION PICTURE PROJECTION

Watts Nominal	Amperes	Volts	Rated Efficiency, Lumens per Watt	Source, Width and Height, In.	Bulb Diameter, In.	Light-Center Length, In.	Maximum Over-All Lg'th Inches	Base
600	20	28 to 32	25.1	0.37 by 0.40	2½	4¾	9½	Mog. Screw
900	30	28 to 32	26.2	0.43 by 0.50	2½	4¾	9½	Mog. Screw

*Distance between center base contact and center of light source.

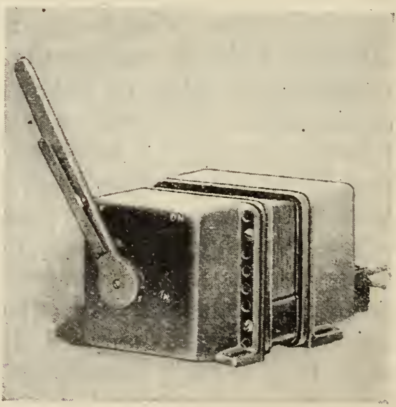


FIG. 381

Alternating-Current Regulator for Reducing Standard Light and Power Circuit Voltages to 28-32 Volts for Mazda Lamps

Experience in theatres indicates that in general the 900-watt lamp with proper equipment gives excellent screen illumination for theatres and auditoriums having a seating capacity on the main floor up to 800 where the distance from the projector to the screen does not exceed 100 feet and where the picture width is not over 16 feet. Under the most favorable conditions of screen surface, house illumination, and location of screen and

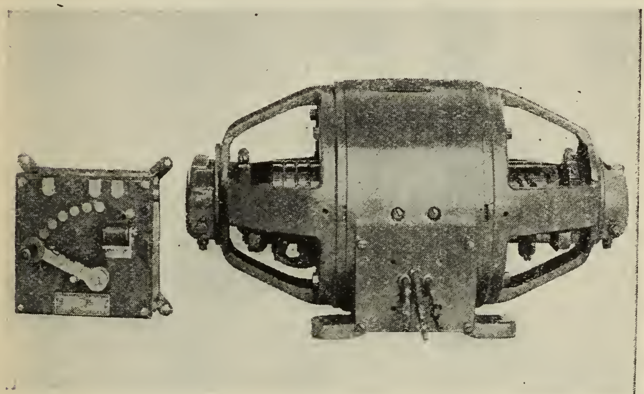


FIG. 382
Rotary Converter Furnishing Alternating Current for Mazda Lamps from Direct-Current Light and Power Circuits

projector with reference to the audience, it gives desirable illumination for houses having a seating capacity on the main floor up to 1000, and a distance from the projector to the screen up to 120 feet. For very wide houses or those with high balconies for which a diffusing screen is necessary, shorter limits should be placed on the throw.

It is assumed in the above statements that No. 2 objective lenses are in all cases employed for focal lengths of 5¾ inches and above and that the screen surface is maintained in good condition. From a 600-watt lamp, 80 per cent as much light is directed to the screen as with the 900-watt equipment. The 600-watt source is designed for

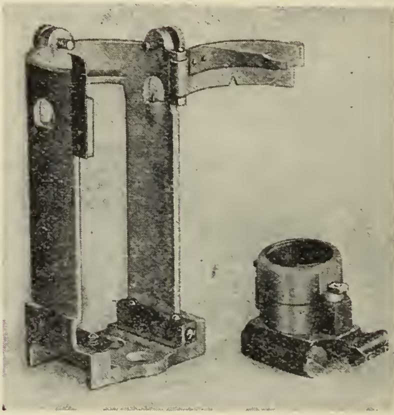


FIG. 383
Lamp Setter and Removable Socket

use in the smallest theatres, in schools, small lecture rooms, etc.; in the small theatres of rural communities not supplied with central station electric surface it is often employed with one of the small 32-volt isolated lighting plants.

The lamps are of the gas-filled construction. Since they are always operated approximately in the vertical position the filament is enclosed in a tubular bulb. This permits the light source to be

placed close to the condenser, which may thus be designed for short focal length and high efficiency, and at the same time results in excellent maintenance of candlepower during life. As the filament slowly vaporizes, the heated gas circulating upward from the filament carries this vapor to the

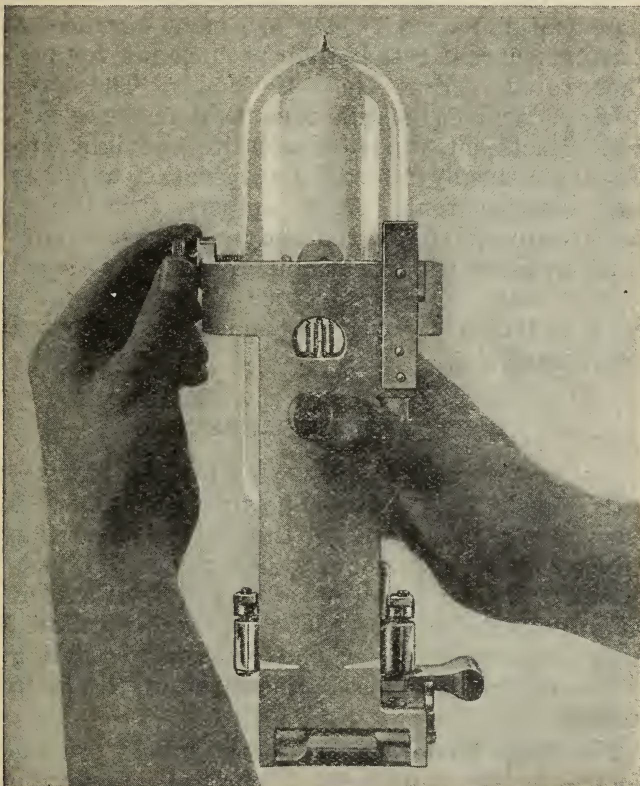


FIG. 384
Lateral Adjustment of Lamp in Setter

upper part of the bulb where it is left on the surface as a dark deposit. The bulb surfaces between the filament and the condenser and mirror are relatively little affected.

Mazda motion picture lamps are designed for operation tip-up within 25 degrees of the vertical; at a greater angle their performance may be somewhat impaired. They are made for use at constant current rather than at constant voltage. Their rated average life is 100 hours. The regulating equipment must be capable of accurate current adjustment, for both lamp life and light output are radically affected by operation at other than rated current. At 31 amperes, the life of the 30-ampere lamp is reduced by about one-half; at 29 amperes the screen illumination is reduced 20 per cent. The importance of operating the lamps at their rated current cannot be emphasized too strongly.

EQUIPMENT REQUIREMENTS

For the proper projection of motion pictures with Mazda lamps, the following equipment is necessary in addition to the optical elements, which have been previously discussed; an adjustable lamp holder or a pre-setter and fixed holder, an adjustable mirror holder, a well ventilated lamp house, an ammeter, and a current regulating device permitting close adjustment of the lamp current.

The lamp holder or pre-setter should provide for moving the lamp vertically as well as laterally along and across the optical axis, and also for rotating it so that the plane of the coils may be

set facing the condenser. The mirror should be independent of, and unaffected by, the lamp adjustments and the mirror holder should allow movement along the axis as well as vertical and lateral adjustment.

To insure good lamp performance it is important to provide ample ventilation of the lamp house with the air circulating over the lamp base and bulb; radiation alone should not be depended upon. The energy dissipated within the lamp house is a minimum with Mazda lamps however, the temperature may become high enough to cause deterioration of the lamp holder, particularly the insulation, if adequate ventilation is not provided.

Since it is very important that the lamp be operated exactly at rated current, an accurate ammeter should at all times be in series with the lamp. It is recommended that the 30-ampere point on the meter scale (or 20-ampere point for the 600-watt lamp) be distinctly marked so that a deviation from the normal current will be at once apparent to the projectionist.

The current regulator should be designed so that for any variation that may be expected in the line voltage, it may be set to give a secondary amperage constant within less than one per cent for any lamp voltage between 28 and 32. This is the range obtaining for individual lamps when burning with reflector, which tends to heat the filament and thus raise its resistance and required voltage. The apparatus should be so arranged that in starting the lamp about half normal voltage is first momentarily impressed so that no failure may result due to unequal heating of the

various parts. Both the ammeter and the regulator control should be conveniently placed so that the projectionist can easily observe the ammeter and quickly take care of any current variations. The

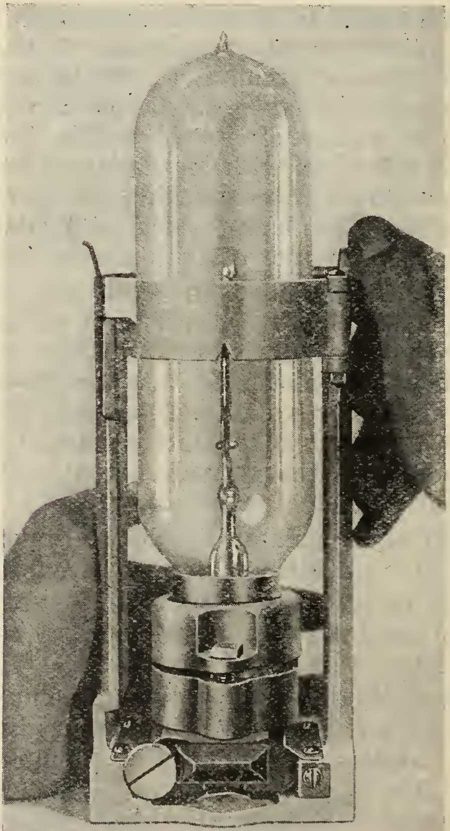


FIG. 385
Alignment of Lamp Filament for Distance from Condensing Lens

ammeter should be calibrated at least as frequently as once every six months.

On alternating current a transformer-regulator should be used to reduce the circuit voltage to that of the lamps. Well designed units have an efficiency of about 90 per cent, making the total wattage required for a 30-ampere lamp about 1000 watts. Either manually operated or automatic regulators may be used; a unit of the former type is shown in Fig. 381.

With direct current, either a motor-generator set, a converter, or a series rheostat can be employed on commercial lighting and power circuits.

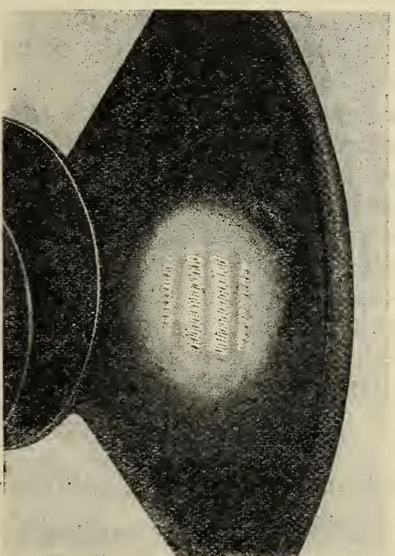


FIG. 386

Filament Image Projected on Rotary Shutter for Observation in Adjusting Lamp

The power consumed in the rheostat is entirely lost. If the lamp takes 30 amperes at 30 volts, when operated from a 115-volt circuit, a loss of 2550 watts occurs in the rheostat as compared with but 900 watts consumed at the lamp. The rheostat handle should always be returned to the "off" or low-voltage position before turning on the projection lamp. A motor-generator set capable of providing the proper voltage at the lamp could be employed with a much lower energy loss. Such a set of 65 per cent over all efficiency would entail a regulator loss of only about 485 watts, as compared with 2550 for the rheostat. The initial investment involved, the cost of maintaining the motor-generator, and the energy cost should all be considered in determining the economy of this equipment.

A rotary converter, for changing the direct current to alternating current, combines the two windings of the motor-generator set on one motor; the cost is less, and efficiency is higher than for the motor-generator set—about 72 per cent over all, including the alternating-current regulator—a loss of only about 350 watts. This new type of equipment, with which the usual type of regulator is employed, is shown in Fig. 382. The installation of such apparatus where direct current only is available is almost invariably an economy.

INSTALLATION OF THE EQUIPMENT

The principal makes of motion picture machines now on the market are easily adapted for use with Mazda lamps. The manufacturers of housings and accessory equipments for Mazda

lamps furnish detailed instructions for adapting the equipment of the projecting machine, and once the installation has been correctly made, there should be no occasion to change it. The centering of the condenser on the optical axis is essential to the projection of a maximum amount of light, and this feature should receive special attention when the equipment is installed.

ADJUSTMENT OF LIGHT SOURCE

Adjustment of the light source is first made without reflector. The lamp is turned so that the plane of the filament coils is perpendicular to the optical axis and it is then moved laterally and vertically until the center of the filament area is in the optical axis. In order that a new lamp inserted at any time thereafter may be exactly placed without delay for adjustment after a burnout, the plan of using removable sockets sliding into guides is to be recommended. To realize this advantage it is only necessary that the initial lamp and those that follow be first aligned in individual sockets in a gauge or pre-setter, such as the device shown in Fig. 383, which provides the four essential adjustments:

1—Height of the filament, by screwing the center base contact up or down until the lower ends of the coils are in line with the two sighting holes in the setter (Fig. 384);

2—Lateral adjustment, by moving the lamp against a spring by means of a thumb screw, until the coils are centered in line with two pointed sights (Fig. 384);

3—Adjustment for distance from the condenser, by means of another thumb screw by which the filament is set in line with two V sights (Fig. 39) at right angles with the plane of the pointed sights;

4—Plane of the filament, by alignment parallel with the V sights (Fig. 385).

The adjustments in the device illustrated are made with the lamp base loose in a special split ring socket which is not threaded; the lamp is fixed in position in the socket by tightening two screws which draw a collar over the split ring, rigidly holding the lamp in its adjusted position in the socket. By opening the hinged top of the setter, the lamp and socket can be removed as a unit with the assurance that when they are placed in the guides provided in the housing, the

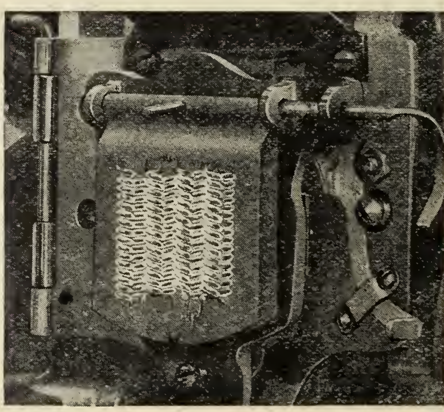


Fig. 387
Pinhole Images of Lamp Filament and Reflected Coils on Fire Shutter for Observation in Setting Mirrored Reflector

lamp filament will be correctly aligned with respect to the condenser and optical axis.

If no pre-setting arrangement is provided in an equipment the best procedure is to place the light source by measurement at the specified distance behind the condenser. Then with the lamp lighted, the spot produced is centered on the aperture plate by moving the lamp vertically and horizontally; this gives an approximate setting of the light source. It can then be made more accurate by intercepting the beam through the open aperture on the rotary shutter or on a black card held where the filament image is most sharp and adjusting the lamp until this image is centered in the illuminated spot as shown in Fig. 386. The attempt is sometimes made to adjust the lamp by centering the image formed on the fire shutter through a small hole in the dowser, but the desired result is usually not obtained because the hole in the dowser is seldom exactly in the optical axis.

ADJUSTMENT OF MIRRORED REFLECTOR

With the prismatic condenser lens, the most satisfactory practical method of setting the mirror is to close the dowser and observe the image of the coils formed on the fire shutter through a small hole in the center of the dowser. For the mirror adjustment it is not important that this hole be exactly in the optical axis. With the lamp operated at normal current, the mirror may be moved into a position where an image of the reflected coils will be observed. The mirror is moved back and forth until this image is of the *same*

size as the image of the filaments. It is then slightly tilted or moved laterally and vertically until the image of the reflected coils appears in the spaces between the coils of the filament image, as shown in Fig. 387. On several of the projection machines the lamp house may be moved to one side. In this case, the image of the coils coming through the dowser hole may be shown greatly enlarged against the wall of the projection room, making it easier to observe the position of the reflected coils. It is very important that the two images be adjusted to the same size. It will be noted that the image of the reflected coils is inverted and reversed; the right segment of the direct image shows as the left segment of the reflected coils.

The most accurate method of setting the mirror is to reduce the lamp current, open the dowser and fire shutter, and to observe the images of the coils on a black card held in front of the objective lens or on the blade of the rotary shutter if the coil images happen to be focused upon it. Its application is limited since a well defined image is not formed outside the projector head where the card can be held, or in the plane of the rotary shutter, except with certain lens combinations.

Where plano-convex condensers are used, the mirror adjustment using the pinhole in the dowser should be supplemented when adjustment must be made while the theatre is in use, by observing the meshing of the filament and reflected coil reflections on the surface of the rear condenser element. The best results with plano-convex condenser equipment are, however, obtained by observing the uniformity of illumination and

color on the screen. One of the limitations of such condensers is the need for this procedure, which is usually impracticable.

Where an accurate mirror adjustment is neglected and the image of the reflected coils is superimposed on that of the coils themselves, materially reduced and uneven screen illumination results. The unevenness of screen illumination is less marked with the prismatic condenser.

The mechanism of a motion picture projector always causes some vibration, hence all clamping screws must be kept tightened to preserve the alignment of the optical elements. The adjustments should be examined from time to time, and in case a lamp is replaced during the progress of the performance, the adjustment should be checked at the first opportunity.

THE COMPLETE EQUIPMENT

A complete equipment in which are incorporated the most recent features of design, including the prismatic condensing lens, a lamp setter, and other desirable features discussed above is shown in Fig. 388. Two plano-convex lenses are mounted on the same holder with the prismatic condenser in such a manner that they can be quickly moved into position for slide projection. This is accomplished by pushing the lamp housing to one side on the base provided; guides and stops limit its movement to the correct positions for motion picture and slide projection. The ammeter is carried on the housing in full view of the projectionist and the regulator is mounted on the base directly behind the housing. The removable

socket and lamp setter shown in Fig. 383 form a part of this apparatus.

Such equipment, designed especially for the Mazda lamp and providing a convenient means of making the necessary adjustments, greatly simplifies the mechanical operations of projection, enables the projectionist to devote close attention to the picture on the screen, and permits the advantages of Mazda lamp projection to be realized to the fullest extent.

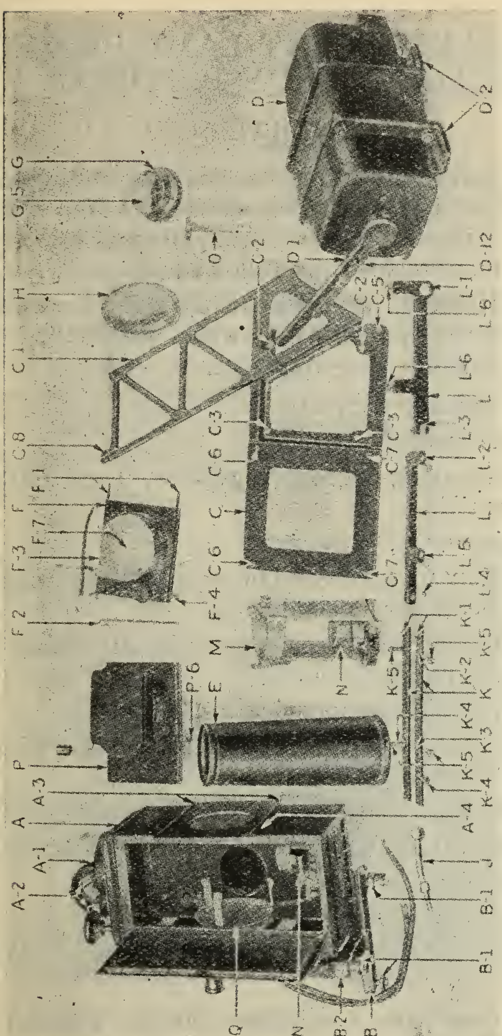


FIG. 388
PARTS AS UNPACKED

G-E INCANDESCENT LAMP PROJECTOR FOR MOTION PICTURES

GENERAL

The following directions for the assembling and operating of the G-E Incandescent Lamp Projector on Simplex, Powers and Motiograph machines should be carefully followed:

The equipment when unpacked should consist of the following parts, as shown in Fig. 388:

A. Lamphouse mounted on—
B. Lamphouse carriage
C. Base bracket
D. Alternating-current regulator, Type HDS, Form E
E. Chimney
F. Motion picture condenser mount complete with prismatic condenser
G. Ammeter and three screws for attaching it to lamphouse
H. Silvered glass spherical reflector
J. General Electric framing handle for Simplex machine
K. Two attaching straps for Powers machine
L. Two attaching supports for Motiograph machine
M. Lamp setter
N. Two universal lamp sockets
O. Center contact key
P. Stereopticon condenser holder (without condensing lenses)

ASSEMBLING

1. HOW TO ATTACH BASE BRACKET ON PROJECTOR

(*a*) *Simplex Projector*

Remove the carbon-arc lamphouse by unscrewing the two lamphouse base wing screws (T-2) under the Simplex lamphouse carriage (T-1).

Place the base (C) on the Simplex lamphouse carriage (T-1) so that the lamphouse carriage track (C-1) extends over the left of the projector when facing towards the screen and then fasten in place with the two lamphouse base wing screws (T-2) that were removed when taking off the carbon-arc lamphouse.

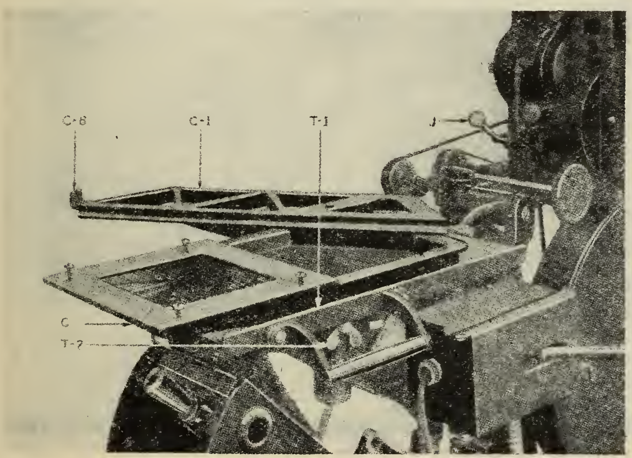


FIG. 389
How to Put Bracket on Simplex Projector

Remove the Simplex framing handle and put in place of it the General Electric framing handle (J) for the Simplex projector.

(*b*) *Powers Projector*

Remove the carbon-arc lamphouse from the sliding carriage (U-1) and replace the cross sliding

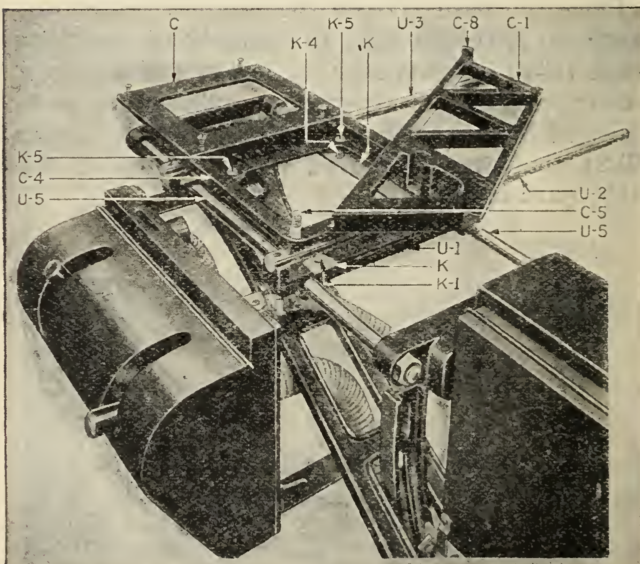


FIG. 390
How to Put Base Bracket on Power's Projector

rods (U-2, U-3), screwing them down in their original position.

Place the base (C) on the cross sliding rods (U-2, U-3) so that the lamphouse carriage track

(C-1) extends over the left of the projector when facing towards the screen. Place the two Powers attaching straps (K-K) underneath the cross sliding rods (U-2, U-3) one on each side, so that the small lugs (K-1) are in front of the front cross sliding rods (U-2) and the front screw holes (K-2) just behind. To correspond with the holes (K-2) and (K-3) in each of the attaching straps, four other holes (C-2) and (C-3) will be found in the front or lower portion of the base (C). The rear attaching screws (K-5) should be slipped down through the holes (C-3) in the base (C) and then each one through one of the small spacers (K-4) and finally screwed into the rear holes (K-3) of the attaching straps. The base should then be lined up with the projector head

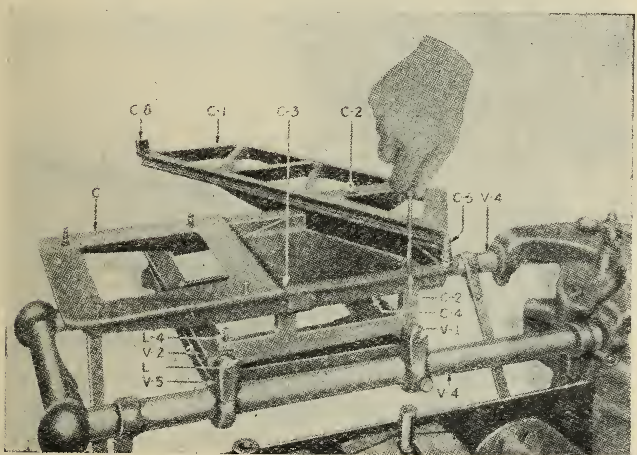


FIG. 391
How to Put Base on Motiograph Projector

(U-4) so that the sides of the base (C-4) are parallel with the sliding rods (U-5) for the Powers sliding carriage and so that the side nearer the projectionist be about $5/8$ in. from the end of the cross sliding rods. Then tighten the four attaching screws (K-5).

(*c*) *Motiograph Projector*

Remove the carbon-arc lamphouse and replace

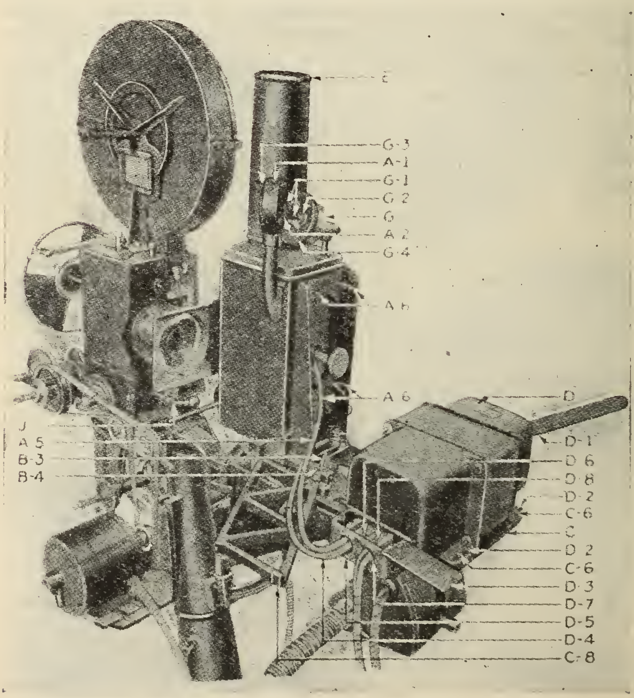


FIG. 392
Assembly of Lamphouse and Regulator on Base

the round front cross sliding rod (V-1) which had to be removed in taking off the carbon-arc lamphouse, passing it through the round cross sliding-rod holes (L-1) in the front of the Motiograph attaching supports (L-L) so that the screw holes (L-2, L-5) are on top. The slot (L-3) in the rear end of the attaching supports should fit into the rectangular cross sliding rod (V-2).

Place the base (C) on the attaching supports (L-L) so that the four attaching screw holes (C-2, C-3) in the front or lower portion of the base correspond with the four screw holes (L-2, L-5)

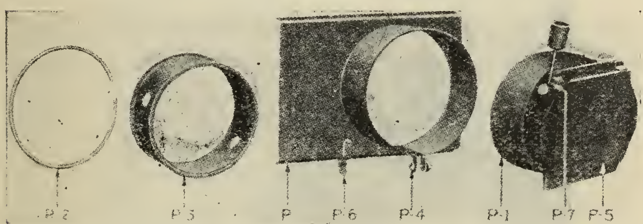


FIG. 393
Parts of Stereopticon Condenser Mount

in the attaching supports, and the lamphouse carriage track (C-1) extends over the left of the projector when facing towards the screen.

Then tighten the four attaching screws (L-6), thereby fastening the base (C) to the attaching supports (L-L). The base (C) should then be lined up with the projector head (V-3) so that the sides of the base (C-4) are parallel with the large sliding rods (V-4) for the Motiograph carriage. The attaching support (L) nearer to the projec-

tionist must be as close to the projectionist as possible. Then tighten the small set screws (L-4) in the attaching supports against the rectangular cross sliding rod (V-2), thereby fastening the base (C) to the Motiograph sliding carriage (V-5). (Attaching straps for the Motiograph De Luxe Projector are special and must be ordered separately, if needed, but the instructions for assembling are the same as those given above.)

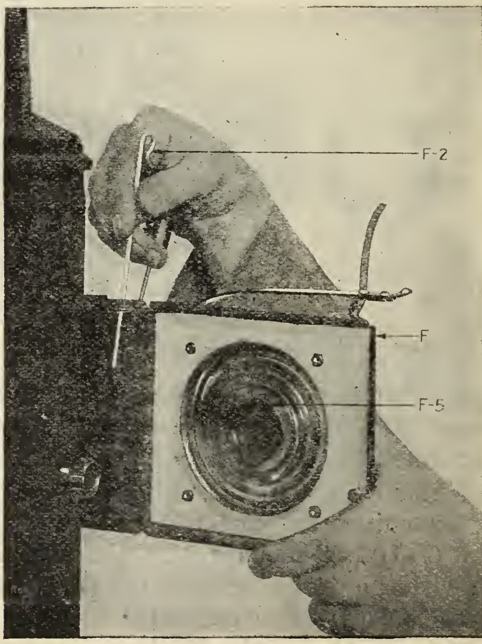


Fig. 394
How to Put Motion Picture Condenser Mount on Lamphouse

2. HOW TO ATTACH THE LAMPHOUSE CARRIAGE WITH THE LAMPHOUSE TO THE BASE BRACKET

Remove the carriage motion picture stop (C-5) on the base (C) by unscrewing it. Place the lamphouse carriage (B) with the lamphouse (A) attached on the carriage track (C-1) as shown in Fig. 19, making sure that the three carriage rollers (B-1, Fig. 1) fit in the grooves of the track. It may require considerable force to fit these rollers in the grooves, but when once in place the carriage should slide easily. If the rollers stick, a little vaseline or oil will help greatly.

After the lamphouse carriage (B) and its lamphouse (A) have been placed on the carriage track (C-1), replace the carriage motion picture stop (C-5) and screw it in tight.

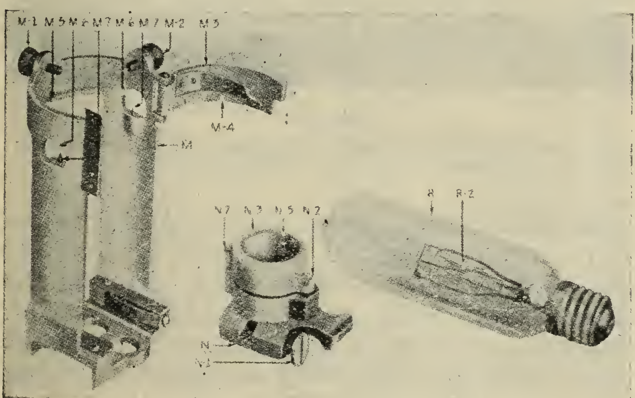


FIG. 395
Lamp, Lamp Setter and Socket

3. CHIMNEY ON THE LAMPHOUSE

Next place the chimney (E) on top of the lamphouse and force the chimney down tight.

4. HOW TO ATTACH THE AMMETER ON THE LAMPHOUSE

Connect the two ammeter lead wires (A-2) protruding from the ammeter support (A-1) attached

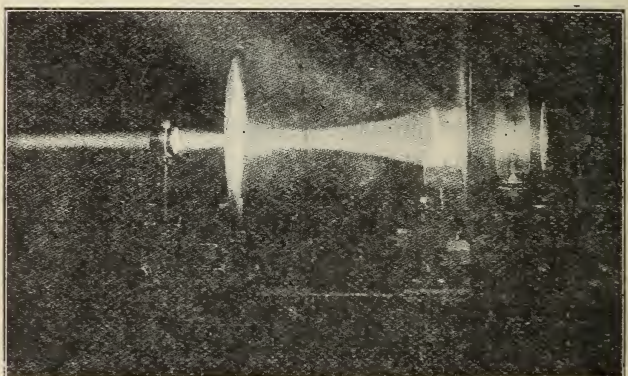


FIG. 396
Light Beam in Motion Picture Projection Using Plano-Convex Condensers and No. 1 Objective Lens

to the upper part of the lamphouse (A) to the two large contact screws (G-1) projecting from the back of the ammeter (G) making sure that the contact nuts (G-2) are screwed down tight. Fasten the ammeter (G) to the ammeter support (A-1) with the three long ammeter attaching screws (G-3) by screwing them from the back of the ammeter support (A-1) into the back plate (G-4) of the ammeter (G).

5. REFLECTOR IN THE LAMPHOUSE

Insert the silvered glass spherical reflector (H) in its holder (Q) (Fig. 388).

6. HOW TO PUT THE STEREOPTICON OR PLANO-CONVEX CONDENSING LENSES IN STEREOPTICON CONDENSER MOUNT

Remove the stereopticon condenser holder (P-1) from the stereopticon condenser mount (P) by loosening the clamping screw (P-4). Then remove the spring retaining ring (P-2) and the

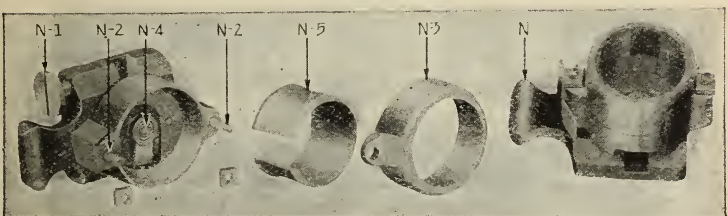


FIG. 397
Parts of Lamp Socket

spacing ring (P-3) from the condenser holder (P-1). Take out the two plano-convex condenser lenses (used with the former carbon-arc equipment), which are usually of 6½-in. and 7½-in. focus. Place the thin one or the 7½-in. focus lens in the holder (P-1) with the flat side of the lens towards the stereopticon condenser dowser (P-5); then insert the spacing ring (P-3) and place the thick or the 6½-in. focus lens on top of this with its flat side uppermost. Hold the condensing lenses in place with the spring retaining ring (P-2). The condensing lenses should now

have their curved sides facing each other, their flat surfaces on the outside.

The stereopticon condenser holder (P-1) may now be inserted in the stereopticon condenser mount (P). The dowser hinge (P-7) should be on the opposite side from the clamping screw (P-4) and the screw should be tightened to prevent the condenser holder (P-1) from falling out of the mount. The slide carrier (P-8) (which should be taken from the former equipment) can now be inserted in place.

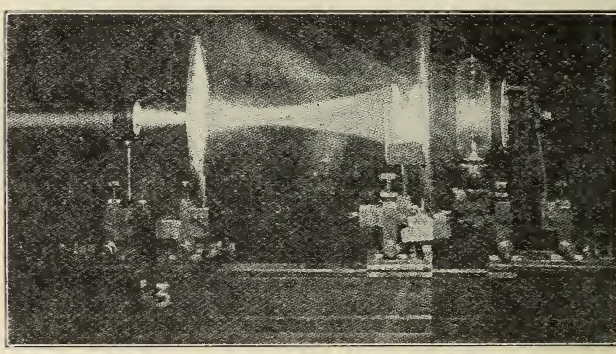


FIG. 398
Light Beam in Motion Picture Projection Using Plano-Convex Condensers and No. 2 Objective Lens

7. HOW TO PUT THE STEREOPTICON CONDENSER MOUNT ON THE LAMPHOUSE

The stereopticon condenser mount (P) should be placed in the condenser guides (A-3, Fig. 388), inserting it from the far side of the lamphouse (Fig. 392).

8. HOW TO PUT THE MOTION PICTURE CONDENSER MOUNT ON THE LAMPHOUSE

Attach the two projecting hinges (F-1) of the motion picture condenser mount (F) to the inside of the stereopticon condenser mount (P) by means of the hinge pin (F-2), keeping the motion picture condenser dowser (F-3) towards the projector head. Then push the motion picture condenser mount (F) over until the motion picture position stop (F-4) hits the condenser stop screw (A-4) on the lamphouse (A, Fig. 388).

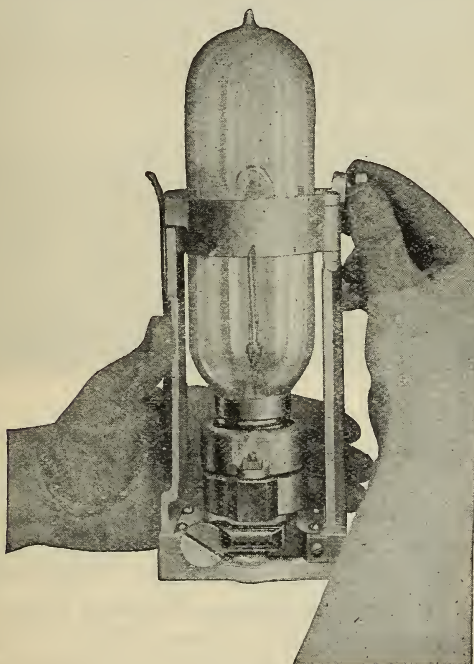


Fig. 399
How to Adjust Lamp in Lamp Setter

9. HOW TO PUT THE ALTERNATING-CURRENT REGULATOR ON THE BASE

Fasten the alternating-current regulator (D) on the base (C) by means of the four screws (C-6) found on the upper or rear part of the base, so that the control lever (D-1) is on the side of the projector facing the projectionist. The four slots (D-2) in the base of the regulator will line up

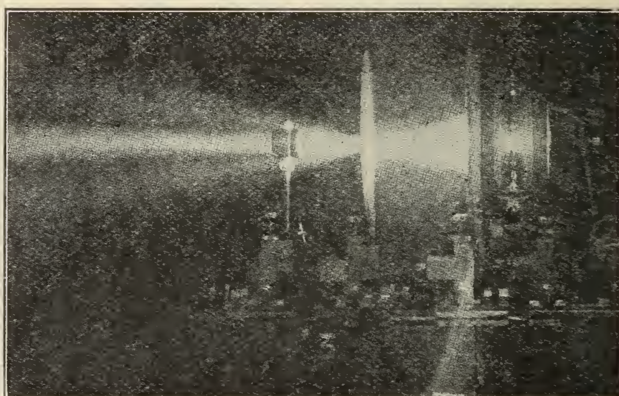


FIG. 400
Light Beam in Motion Picture Projection Using Prismatic Condenser and No. 1 Objective Lens

with the holes (C-7) in the base. Remove the terminal box cover (D-3) and push the lamp leads (A-5 and D-4) through hole (D-5) marked "Lamp" in terminal box and fasten firmly to the two forward terminal screws (D-6). The main line leads are attached in similar manner through hole (D-7) marked "Line" to the two rear ter-

minal screws (D-8). Control lever (D-1) should be in its "off" position before attaching main line leads. Then screw the terminal box cover (D-3) in place. Be sure that the thin leather washer (D-16) is in place on the switch stud before putting on the control lever (D-1). Tighten the small screw (D-17) fairly tight and then set the screw (D-18) securely.

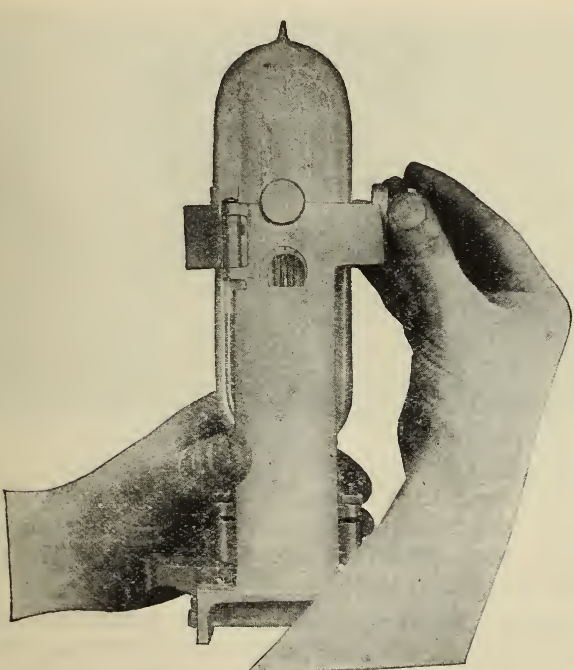


FIG. 401
How to Adjust Lamp in Lamp Setter

10. HOW TO SET AND ADJUST THE MAZDA LAMP IN THE LAMPHOUSE AND LAMP SETTER

Unscrew the large nickel head adjusting screw (N-1) on the socket (N) until it is backed out approximately 3/8 in. to 7/16 in. Loosen the small clamp screw (N-2) until the upper half of the socket (N-3) moves freely in all directions. Unscrew center socket contact (N-4) until it is flush with the bottom of the socket.

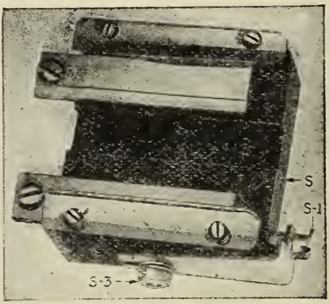


FIG. 402
Socket Base

Insert lamp (R) in socket (N) being sure to push the lamp all the way down so that it can move freely in all directions and not bind. Unscrew the two large knurled adjusting screws (M-1) and (M-2) on the lamp setter (M) and open the gate (M-3).

Insert the lamp socket (N) with its lamp loosely in place in the lamp setter (M) and close lamp setter gate (M-3). Turn the lamp in its socket until the edge of the filament is parallel with the notch in the gate (M-4) and the notch in

the frame (M-5) opposite. Then by means of the focusing screw (M-2) line up the filament with the notches mentioned above. (See Fig. 399.)

Sight through the two sighting holes (M-6) and raise the lamp by screwing up the center contact (N-4) from the bottom with the center contact key (O) until the bottom of the filament coils (R-2) is flush with the lower edges of the sighting holes (M-6).

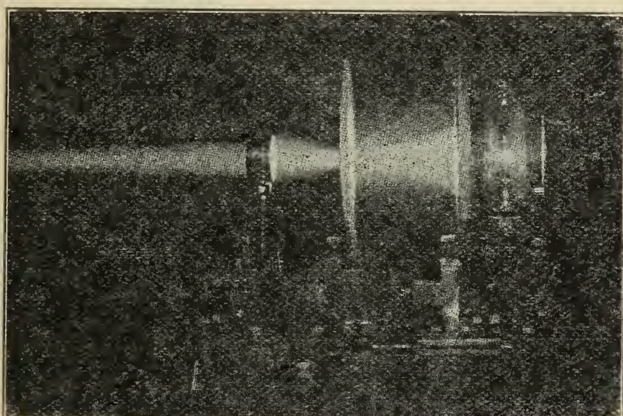


FIG. 403
Light Beam in Motion Picture Projection Using Prismatic Condenser and No. 2 Objective Lens

Then as conditions demand tighten or loosen the knurled lateral adjusting screw (M-1) until the two line-up pins (M-7) in the sighting holes (M-6) come exactly between the two center coils of the filament.

If the lamp filaments are not now vertical they may be made so by screwing or unscrewing the

large nickel adjusting screw (N-1) on the socket. Then the location of the filament with respect to the lining-up pins (M-7) should be checked.

Then tighten or loosen the knurled focusing adjusting screw (M-2) on the lamp setter until the filament is in line with the two notches (M-4 and M-5, Fig. 399).

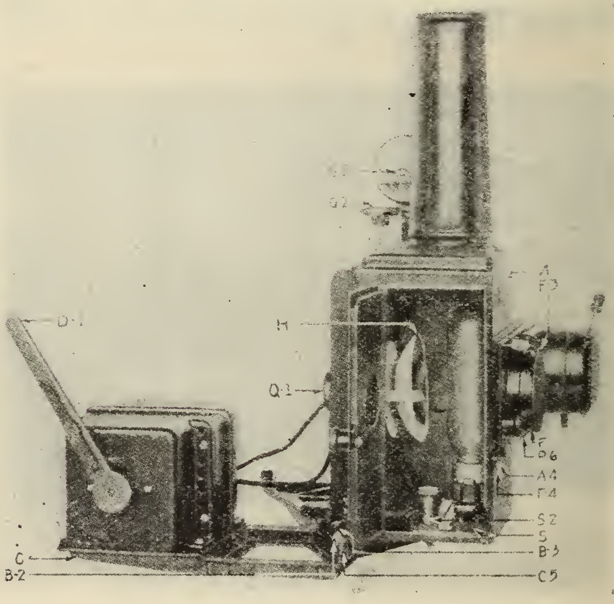


FIG. 404
Interior of Lamphouse with Lamp in Position

Check the vertical adjustment (the position of the lamp filament) Fig. 400 and the focusing adjustment (the location of the filament in the notches) Fig. 399.

Tighten socket clamp ring (N-5) by screwing up the clamping screws (N-2) thereby locking the lamp in position in the socket.

Gently screw up bottom center socket contact (N-4) against the lamp so as to insure good contact.

Open lamp setter gate (M-3) and unscrew the knurled adjusting screws (M-1 and M-2) until

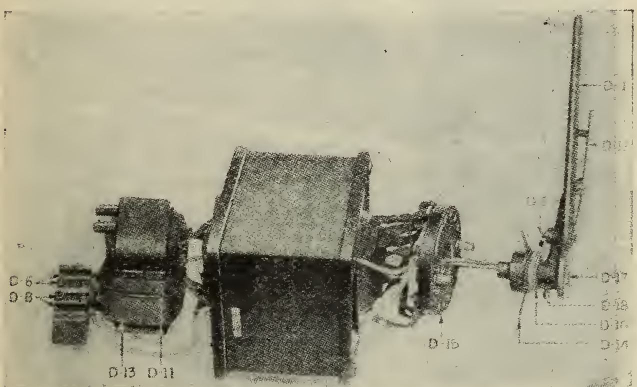


FIG. 405
Parts of Type H.D.S., Form E, A. C. Regulator

they do not touch the lamp. Check the lateral adjustment through the sighting holes (M-6) and, if found to be slightly wrong, correct by screwing or unscrewing the large nickel adjusting screw (N-1) on the socket (N). *This precaution is very important.*

The socket with its lamp may now be taken out of the lamp setter with the assurance that the lamp will always be in correct position for pro-

jection provided the lamphouse and motion picture condenser and socket base adjustments have been made.

Insert socket and lamp as far as it will go in the socket base (S) in the lamphouse (A, Fig. 402 and 404).

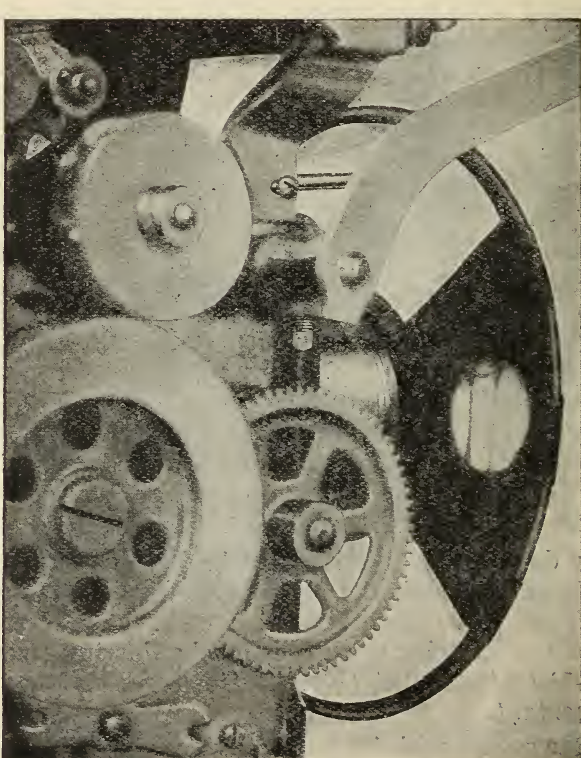


FIG. 406
How to Adjust Lamp in Socket

OPTICAL ALIGNMENT

In order to secure the maximum screen illumination possible the projecting lens, the aperture, the condensing lens and the lamp filament must be exactly on the optical axis of the optical train of the projector, because if any one of these elements has its center as little as 1-16 in. off this optical axis, the screen illumination will be greatly reduced.

Raise the automatic fire-shutter or open the gate of the projector. Pull the lamphouse (A) over until the carriage adjusting screw (B-2) hits the carriage stop (C-5) on the base (C) and push the motion picture condenser mount (F) over until its stop (F-4) is against the stop (screw A-4) on the lamphouse. (See Fig. 404.) Move the base (C) forward or backward until the front surface of the bulls-eye of the prismatic condensers is 6½ in. from the edge of the aperture (except where state laws compel a greater distance) and fasten the base against further movement. Turn the fly-wheel until the revolving shutter of the projector has opened the projection lens.

The remaining adjustments must be made with the lamp lighted. (See Fig. 405 and 415.)

Move the control lever (D-1) of the Type HDS, Form E, alternating-current regulator clockwise until the pin (D-9) strikes the stop (D-10). When the control lever (D-1) is in this position the current passes through the warming reactance or choke coil (D-11), which prevents a sudden rush of current to the lamp filament at the start and merely brings the filament to a glow.

Then push in the auxiliary lever (D-12), thereby releasing pin (D-9) and slowly move control lever (D-1) clockwise until the ammeter needle (G-5) registers 30 amperes. As the control lever (D-1) is moved further in a clockwise direction, more and more current is allowed to flow through the primary coil of the regulator and a correspond-

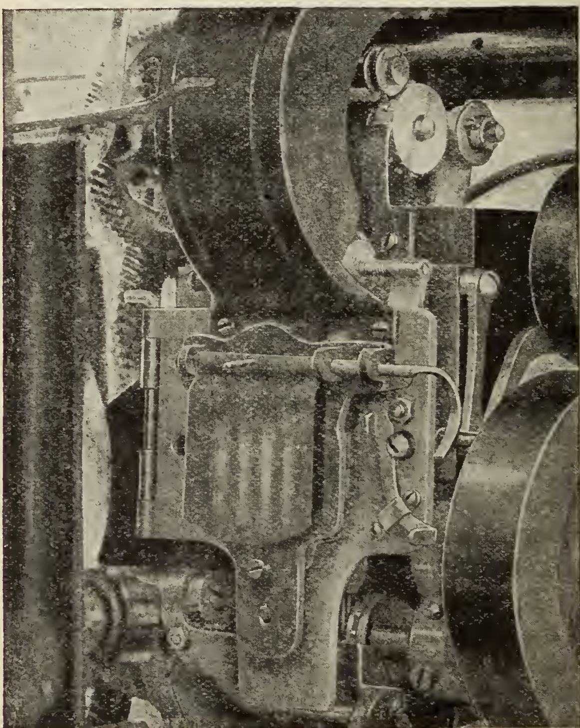


FIG. 407
Filament Reflection on Fire Shutter

ingly greater current through the lamp filament. Momentary drops in illumination as the contact fingers (D-14) of the dial switch (D-15) move from one contact to the next are prevented by the contact reactance (D-13). To shut the current off, reverse the operation by turning the control lever (D-1) counter-clockwise until it stops, thereby opening the circuit on the primary side of the regulator. After the lamp is lighted, place a piece of dark-colored, low, reflecting cardboard (usually the terminal box cover (D-3) will prove satisfactory) and move it forward and backward in front of the projection lens, until the rings of the condenser are sharply focused on it. Loosen the four wing nuts (A-6, Fig. 392) on the back of the lamphouse and raise or lower the lamphouse until the same number of rings show up and down on the cardboard. After the image of the condenser is thus centered up and down, tighten the four wing nuts (A-6).

Next move the lamphouse to and fro on its carriage track until the same number of rings show on either side or laterally by screwing or unscrewing the carriage adjusting screw (B-2). Be sure that, when the prismatic condenser rings are centered, the motion picture position stop (F-4) is shoved over against the condenser stop-screw (A-4) and that the carriage adjusting screw (B-2) is against stop (C-5, Fig. 404). Set-screw (B-3) should now be tightened. The prismatic condenser (F-5) is now on the optical axis with the aperture and projection lens. Place the revolving shutter about ½ in. in front of the projection lens and turn the shutter until one of its blades intercepts the beam of light (Fig 406).

Tilt the reflector up by moving its focusing knob (Q-1, Fig. 404) down and lock with locking knob (Q-2). Place the image of the filament in the circle of light on the shutter blade (Fig. 406). If the filament images are too far to the left, screw in the contact base adjusting screw (S-1) and push the socket (N) farther into the lamphouse. If the images are too far to the right, unscrew the

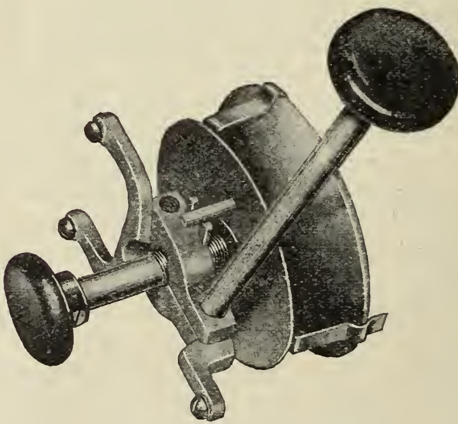


FIG. 408
Parts of Reflector Holder

contact base adjusting screw (S-1), thereby pulling the lamp out from the socket base (S). The space between the two center coils of the filament should be in the center of the circle of light. (The filament image on the shutter may or may not necessarily be sharply defined and distinct.)

Loosen the socket base clamp (S-2, Fig. 404) and move the lamp forward and backward until the

distance of the filament from the back face of the prismatic condenser is approximately 2¼ in. and then tighten the socket base clamp (S-2). Check the images on the shutter blade and, if correct, tighten the lock-nut (S-3, Fig. 402.)

The optical strain is properly lined up if the prismatic condenser rings, as imaged on the cardboard, are perfectly centered both vertically (up and down) and laterally (sidewise) the filament image is in the center of the spot of light on the shutter blade (Fig. 406), the spot of light on the cooling plate is small and centered, the lamphouse carriage (B-2 is against its stop (C-5, Fig. 404) and the motion picture condenser mount (F) is against its stop (A-4, Fig. 404). Then close the motion picture dowser (F-3) and the automatic fire-shutter. An image of the filament will be projected on the automatic fire-shutter (Fig. 401) through

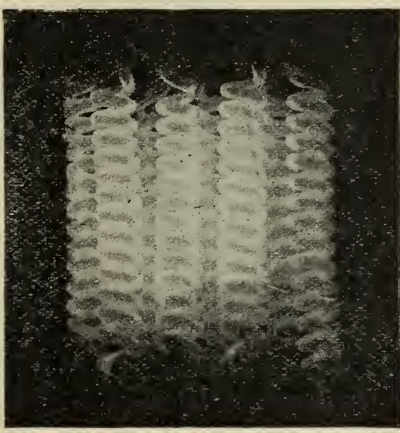


FIG. 409
How to Mesh Reflector Image

the pin hole (F-7). The fact that the image is off center with respect to the aperture does not indicate that the line-up is incorrect.

Loosen locking knob (Q-2, Fig. 404) and move the reflector (H) forward or backward by means

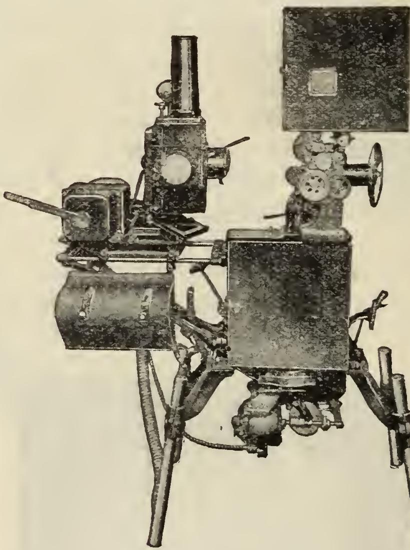


Fig. 410
How to Adjust for Stereopticon Projection

of focusing knob (Q-1) until the reflector image of the filament as projected on the fire-shutter is exactly the same size as the filament image (Fig. 409). Turning the focusing knob (Q-1) clockwise will make the mirror image smaller; turning it counter-clockwise will make it larger.

After the reflector image is of the same size,

move the focusing knob (Q-1) to and fro, up and down until the mirror image of the coils meshes into the open spaces between the filament coils, thereby making a uniform source of light. Then clamp the mirror in position by tightening locking

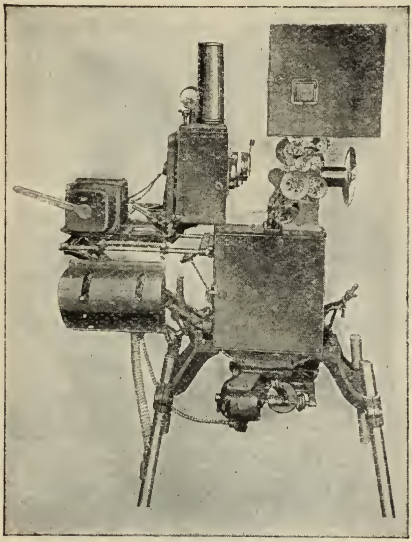


FIG. 411
Complete Unit on Power's Projector

knob (Q-2, Fig. 404). If this lamp be now removed, and another lamp (correctly set up in the same lamp-setter) be inserted, the mirror image will mesh correctly as before (Fig. 407) ; but if it does not fall exactly between the filament coils, move the reflector slightly one way or the other until the fault is remedied *but do not touch the lamp socket or the adjusting screws* (*N*-1 *or* *S*-1).

ADJUSTMENTS

HOW TO ADJUST FOR STEREOPTICON PROJECTION (Fig. 410)

To adjust for stereopticon projection push the carriage (B) over on its track (C-1) against the stop (C-8). Then pull the motion picture con-

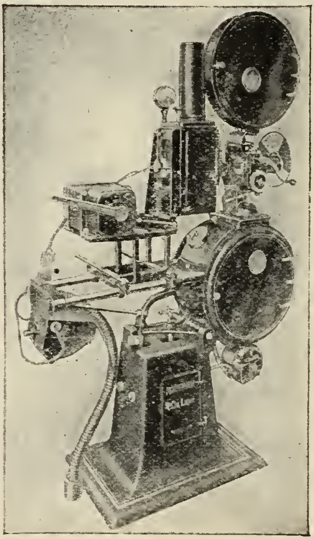


FIG. 412
Complete Unit on Motiograph Projector

denser mount (F) over until the stereopticon stop (P-6) hits condenser stop-screw (A-4) on the lamphouse. Bend back the motion picture condenser mount (F) on its hinge (F-1) against the lamphouse until the stop (F-4) engages in latch (A-7).

The setting of the lamp with respect to the plano-convex condensing lenses is done by moving the stereopticon condenser holder (P-1) backward and forward until the field is clear instead of moving the lamp itself to and fro as is the case with the carbon arc. This distance for the lamphouse carriage (B) to be moved over may be controlled by loosening the set screw (B-4) and by varying the distance of the stereopticon position-pin (B-3) to the stop (C-8, Fig. 392).

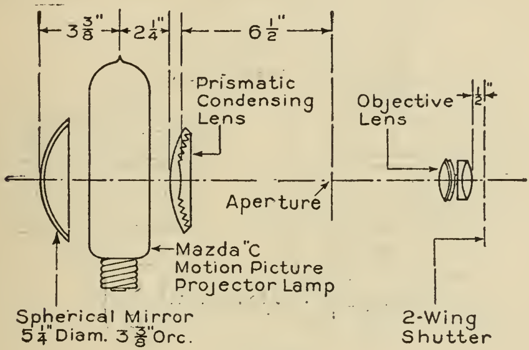


FIG. 413

Mechanical and Optical Line-up for Incandescent Motion Picture Projection

WHAT TO DO IF THE LINE IS DIRECT OR CONTINUOUS CURRENT INSTEAD OF ALTERNATING CURRENT

When only direct or continuous current is available, the use of an "inverted synchronous converter" to change the direct or continuous current to an alternating current is recommended, and the foregoing instructions should be used. The synchronous converter (Fig. 416) should be connected

to the line and to the regulator, as shown in the diagram (Fig. 417). Since the synchronous converter delivers an alternating current at 25 cycles and 78 volts or 156 volts (depending on whether 110 volts or 220 volts, direct or continuous, are received from the lines) it will be necessary to state what type of alternating-current regulator is to be used. It is recommended that the synchronous converter and regulator be used instead of a fixed and variable rheostat on account of the greater economy of operation. If, however, fixed and variable

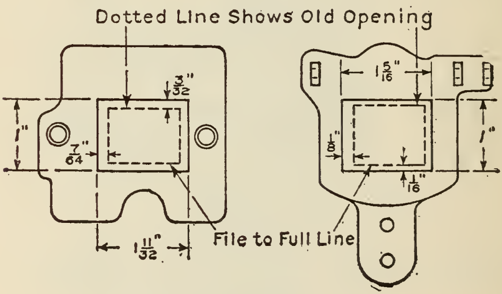


FIG. 414

resistances are used, directions and instructions for their use will be furnished separately.

There are times when there are three projectors in a booth. Under these conditions, the regulators should be connected to the synchronous converter as shown in the wiring diagram, Fig. 418. In this connection it must be noted that two lamps should *never* be operated on the same phase, and consequently regulator No. 2 should be connected to both phases through a 10-amp., double-pole,

double-throw switch. For example, let regulator No. 1 be lighting lamp No. 1 on phase No. 1. When time to change from regulator No. 1 to regulator No. 2 make sure that the switch "Z" is in

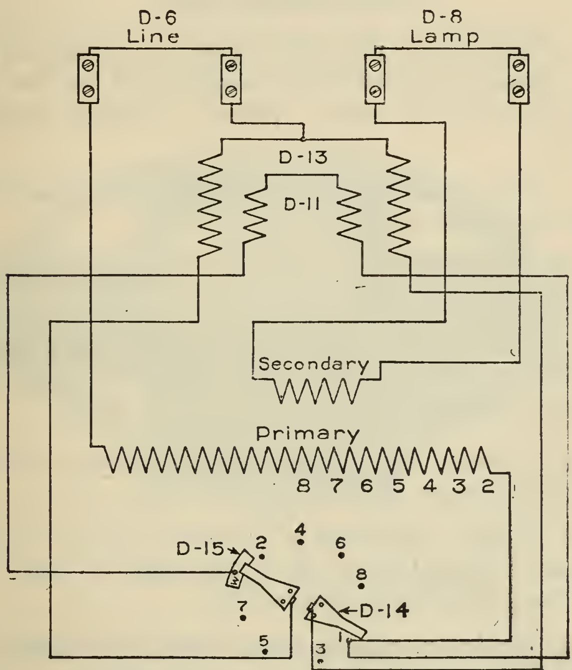


Fig. 415
Connections of Type HDS, Form E, A. C. Regulator

the phase No. 2 position. When it is nearly time to change from regulator No. 2 to regulator No. 3, throw switch "Z" over quickly from phase No. 2 to

phase No. 1, then when regulator No. 3 is thrown on these two regulators will be on different phases.

It is recommended that a starting box be used when operated on a 220-250-volt, d-c. line.

RECOMMENDATIONS

In addition to the above specific instructions we recommend the following suggestions for the improvement and better upkeep of MAZDA Projection:

1. Use that type of projection lens designed for the Mazda lamp.

2. Use the largest diameter (that is No. 2) projection lens possible.

3. The openings in the cooling plates on the projector should be enlarged by filing to the dimensions shown in Fig. 414.

4. Always use a two-blade revolving shutter having opaque blades.

5. If the projection is downward at any angle greater than 10 deg., it is desirable to turn the lamps around quite frequently.

6. Reflector and condenser should be washed or at least wiped frequently to remove dust.

7. Lamps should be removed from the lamphouse when the filament is distorted or warped so that it is impossible to properly mesh the mirror image. They should seldom, if ever, be discarded due to blackening of the bulb.

OPERATING HINTS

Keep ammeter at or below 30 amperes.

See that the reflector and condenser are clean.

See that the reflector image is properly set.

See that spot fits aperture.

Keep an extra focused lamp on hand.

Remember that the lamp bulb is not made of sheet iron but of glass and treat it accordingly.

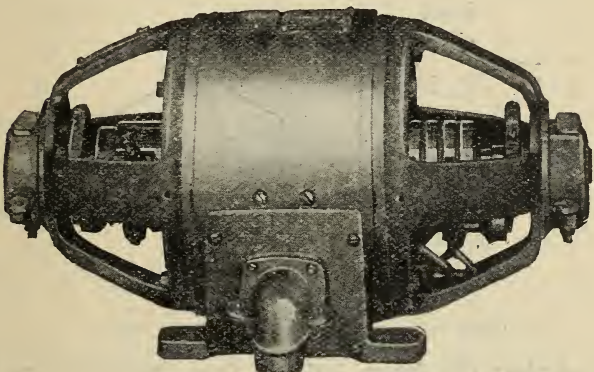


FIG. 416
D. C. to A. C. Synchronous Converter

Don't imagine you can get good results without the proper amount of "Know How." Anyone can light a lamp, but it takes a wise man to get 100 per cent service out of it.

Don't put up with an ordinary muslin screen. The days of muslin screens and plaster walls are rapidly passing.

If you need more light on the screen invest in a larger diameter projection lens. A large lens costs more than a regular size one, but if it gives you the results, it is certainly worth the few extra dollars.

Clean your condenser and your mirror every day.

Remember you are operating a Mazda lamp and not an arc. A Mazda lamp requires skill and care.

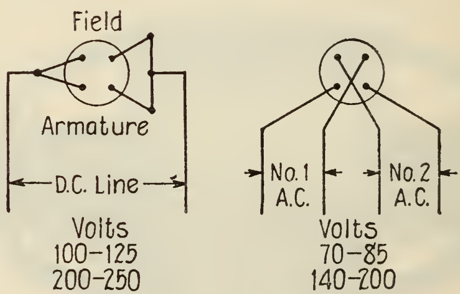


FIG. 417
Connections for Synchronous Converter

See that the lamp bulb is free from dirt and finger marks.

TROUBLES

LAMP WILL NOT LIGHT

Is main switch on?
Are connections correct?
Is the lamp filament broken?
Is the lamp tight in its socket?
Do contact slides make contact?
Is the center contact screwed up?

SCREEN

Badly Streaked

Is reflector set properly?
Is reflector clean?
Is lamp filament badly warped?

Yellow Streaks

Is lamp at 30 amperes?
Is reflector clean?

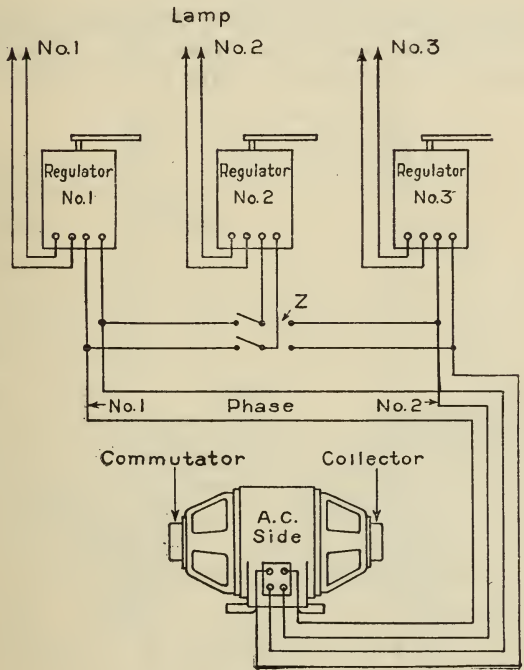


FIG. 418

Connections for Synchronous Converter, Three Regulators, for 230 Volts D. C. Supply

Dark All Over

Is lamp in focus?
Is spot on aperture?
Is system in alignment?
Is reflector properly set and cleaned?
Is filament badly warped or twisted?
Does port hole, if masked in, cut off any light from lens?

Dark on One Side

Is spot on aperture? Move lamphouse sidewise till screen illumination becomes even. (Note filament position on circle of light on shutter.)

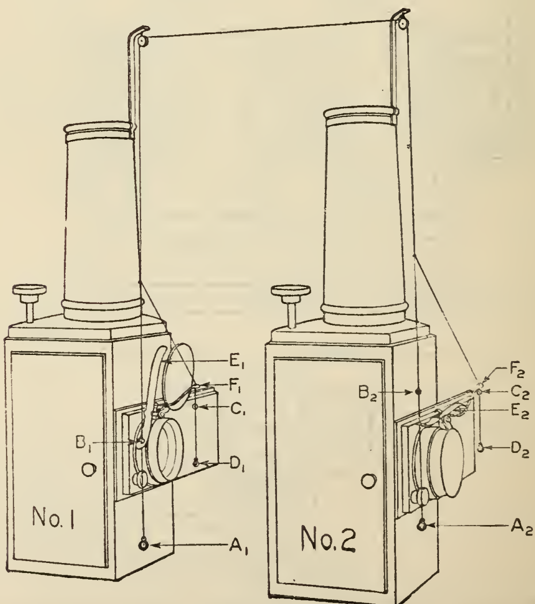


FIG. 418
Simple Method for Change-Over

Dark on Top or Bottom

Is lamphouse of correct height? Note position of condenser ring on cardboard in front of shutter; also check position of lamp in lamp setter.

IF LAMPS BURN OUT EARLY IN LIFE

Over amperage? Check the ammeter. Check the position of the ammeter needle at zero to be sure that it registers correctly. If the needle does not point exactly to zero when the lamp is turned off, it may be reset by means of the small screw at the bottom of the case.

LAMPS BLACKEN RAPIDLY

Over amperage? Check the ammeter.

Excessive heating? Examine the electrical connections.

The sketch shown in Fig. 419 shows a very convenient, satisfactory and simple method of obtaining change over from one projector to the other with perfect fading. This method is employed in many houses.

Suspend a couple of pulleys (A, A-2) from the lamphouse chimney, or from the ceiling; thread with fishline the two dowser parts, as shown in the diagrams b, b2 and c, c2; bring small nuts tied into the string and (d, d2) small counter weights.

Suppose the dowser on lamphouse number 1 to be open. Then, by pulling down string A-2, knot b2 will pull down on handle C-2, open the dowser on lamphouse number 2, and, as the string A-2 is pulling downward, it pulls knot c up against the dowser trip f, releasing the dowser on lamphouse

number 1, thereby shutting off the light. The string may then be let alone, and the dowser catch will keep dowser number 2 up. Pulling down string A, when the dowser on lamphouse number 2 is open, will open that on lamphouse number 1 and shut that on number 2.

ELECTRICAL APPARATUS FOR THE STUDIO

The question of whether alternating or direct current should be used in the production or projection of motion pictures is no longer open for argument.

Studio engineers and projectionists are quite familiar with the decided advantages of direct current from the standpoint of both economy and good illumination. In fact, a comparison of the cost of operation per candle power and the relative photographic value is so much in favor of direct current that it is almost universally employed. To-day, alternating current for motion-picture work can be considered a deviation from standard practice.

A motor generator is conceded to be the most satisfactory piece of apparatus to convert A. C. to D. C. for use in the studio. Before proceeding, however, into the discussion of generating and converting equipment, let us consider briefly the respective requirements for satisfactory illumination in the studio, then we shall discuss in a general way the design of apparatus suitable to meet these requirements.

For best results in studio lighting, the Mercury Vapor tubes for producing the soft lights as well as the arcs used for contrast hard lights, and "close-ups," must be supplied with a very steady direct current. The motion-picture negative is very susceptible to fluctuations in light resulting from unsteady voltage; therefore, generating or

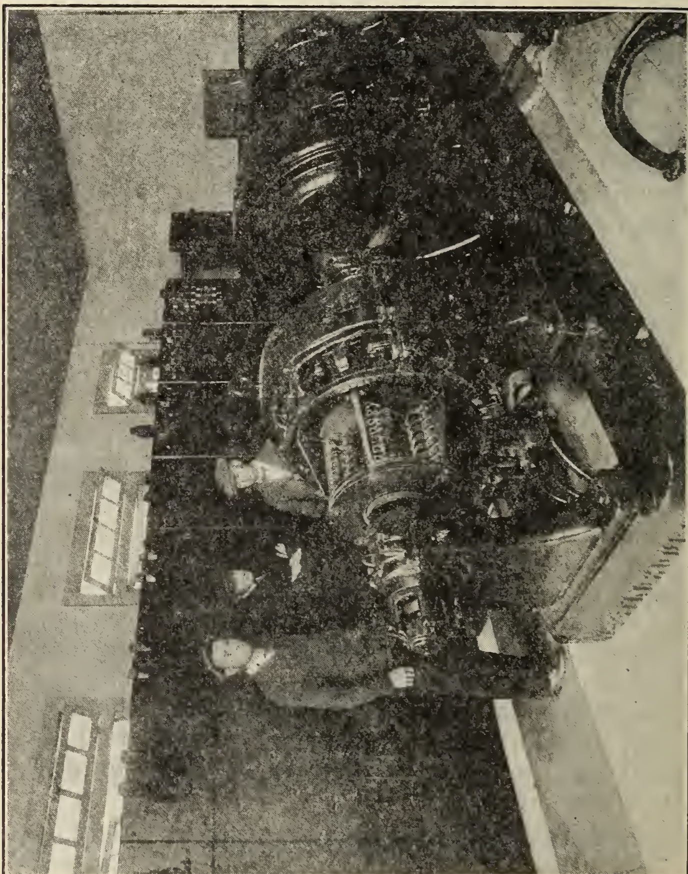


FIG. 420

Three Unit Motor Generator for Studio Lighting, Consisting of Two 150 Kil. Generators and 50 Cycle Induction Motor. Part Installation in Robert Brunton Studios, Los Angeles, Cal.

converting apparatus, suitable for stage lighting, must have electrical characteristics to conform with this essential requirement.

Economical distribution is of unusual importance in the studio on account of the large number of circuits and heavy currents handled. The three-wire system is used considerably because of the saving in copper in making the installation.

In connection with the three-wire system of distribution, a very important item is the matter of flexibility. The studio director is very apt to call for "lights" or a change in the illumination, which would result in an unbalanced circuit greatly in excess of that for which commercial three-wire generators or converters are designed. Even if it were possible for the electrician to connect the circuits so as to obtain a balanced condition, the time required to make the proper connections would prove a detriment to rapid production. Every minute counts—time is very valuable in present-day production of motion pictures. Also the matter of convenience should be given consideration. Assuming that the load could be kept balanced, or nearly so, by making the proper connections, this work of plugging in the different circuits so as to obtain a nearly balanced load would prove very inconvenient. For these reasons this frequent condition of large unbalanced loads introduces a great objection to the application of commercial three-wire apparatus which are only designed to carry not over 25 per cent. unbalanced current.

Three-unit motor generators meet all the requirements indicated above. They consist of two 115 volt, flat compound, direct-current generators,

mounted on a common base with and directly connected to a synchronous or induction motor of the proper characteristics.

In modern studio design, the greatest problem before any studio engineer is undoubtedly that of adequate and proper facilities for lighting the various stages. The arrangement of stages and the locations of lights are generally known to be the most uncertain features in the operation of a studio. This condition requires the utmost flexibility, therefore the control of the studio lighting in large projects and the arrangement of the elec-

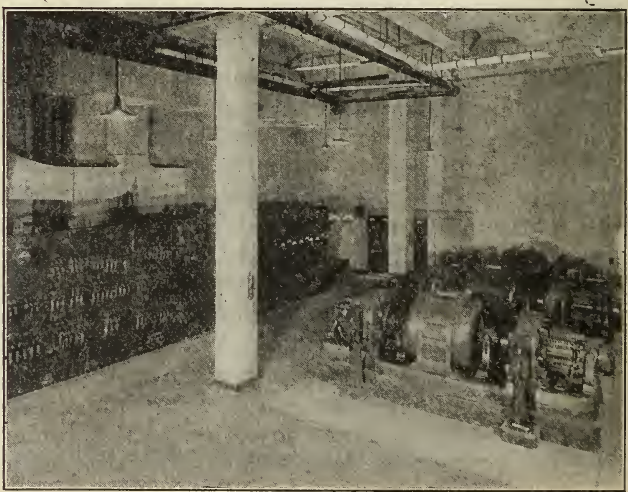


Fig. 421

7600-Volt Sub-Station and Motor Generator Plant, Famous Players-Lasky Corp.

trical equipment is a matter of prime consideration.

In the early days of the motion picture studio, the lighting equipment was arranged in a manner similar to that of the legitimate theatre stage and very little thought was given to the entirely different character of the work executed in the studio. In the beginning this make-shift was not so noticeable, due principally to the fact that the industry was "feeling its way" and had not yet started to broaden out into an established industry requiring intensive production. Studios of more than one or two stages were unknown and probably unthought of. Instead of a number of different pictures or scenes being filmed at the same time in the same building, usually one complete picture or serial was finished before another one was begun. There was employed during this time only one director. The studio itself was still in an experimental and development stage, as were other branches of the industry.

In studios where sunlight was not used, cables were strewn haphazardly across the floors and hung or festooned across the structure of the building from a central switchboard to the various stages for supplying the floor and overhead lamps. The lamps were controlled by men stationed both at the lamps and at the switchboard. The men operating this equipment received signals and instructions, from the director or camera man, which were supposed to be executed properly, promptly and in synchronism. As happened quite frequently the misunderstanding of the signal by a single man meant a retake of the entire

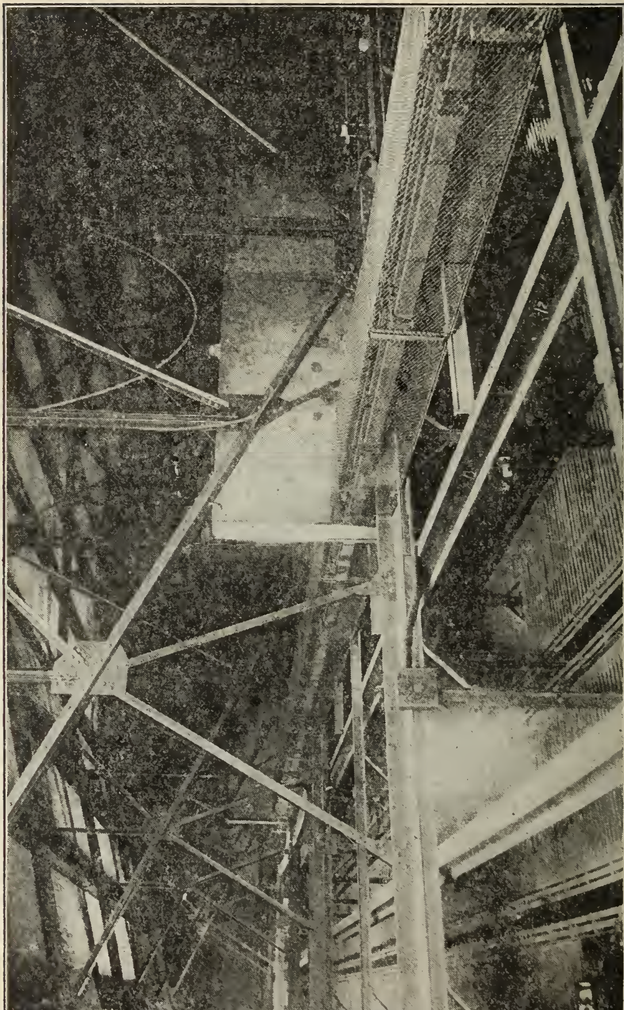


Fig. 422
Main Bus Bar Feeder Running Through Roof Space and Overhead Switchboards

scene, loss of time for players, directors and stage hands. Strange to say, many of these conditions have carried over to a fairly recent period, and it is only within the last two years that any great strides have been made in the efficient and proper electrical distribution and control of artificial lighting for studios.

The method of arranging the lights to be controlled by the director or camera man promptly, efficiently and without errors was one of the first questions to be considered.

A problem which presents itself in modern studios is the design of a suitable equipment which can be used by several directors simultaneously working on adjacent stages, without interference with each other.

This article describes only generally the various considerations and engineering problems which go into the design of many of the special features in these projects and is not intended to present the electrical engineering of the problem with its many technical calculations and computations leading up to the results obtained. As previously stated, to obtain direct current supply for the studio it is customary and good "practice" to install 3-circuit motor generator sets which will supply 3-wire system at 250/125 volts. The motor generators of this type are arranged with two generators mounted on a common shaft on either end of the driving motor.

As previously stated, this system of distribution is the most economical, but the possibilities of unbalancing such a system in a studio are very great. With the standard type 3-wire generators

as are ordinarily furnished for commercial work, the percentage of unbalancing of load on either side of the three-wire system is rarely if ever permitted to be more than 25%, which is the maximum capacity of the special balancing coils, balancer set or compensating taps inside of the ma-

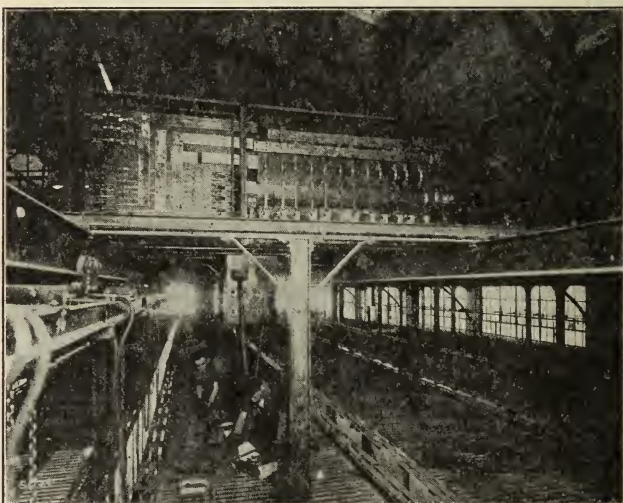


FIG. 423
View Showing Remote Control Switchboard and Six-Gang Plugging Box

chine. However, in studios, the nature of the load is such that the percentage of unbalancing is very high and sometimes reaches as much as 100%. There is no commercial type three-wire generator made which will operate under these

conditions and the universal practice, therefore, now seems to lean toward the application of three-unit sets where the two generators on the same set are connected in series to obtain the Edison 3 to 2 wire system in identically the same manner as it was employed by the large central stations in the early days of the Edison three-wire system. The neutral or middle leg of this system is connected to the tie between the positive lead of the one machine and the negative lead of the other.

The main switchboard should be specially designed and constructed for the control of the motors and generators. Studio circuit breaker sections should be located on separate panels of the switchboard and equipped with two-pole circuit breakers and three-pole knife switches with ample space for recording instruments. All the various generator leads should be brought to the main switchboard with the exception of the equalizer leads, which may connect to knife switch pedestals, two of which are installed with each motor generator set. The generator sections of the switchboard should each be equipped with safety stop devices and the circuit breakers interlocked with the main motor oil switches, preventing the operator from throwing the generators on to the direct current bus bars unless the motor driving the generators is running. The motor generators should be equipped with over speed devices which will trip out the main motor oil switches should the machines get out of step.

The motors and generators should be standard 40° design.

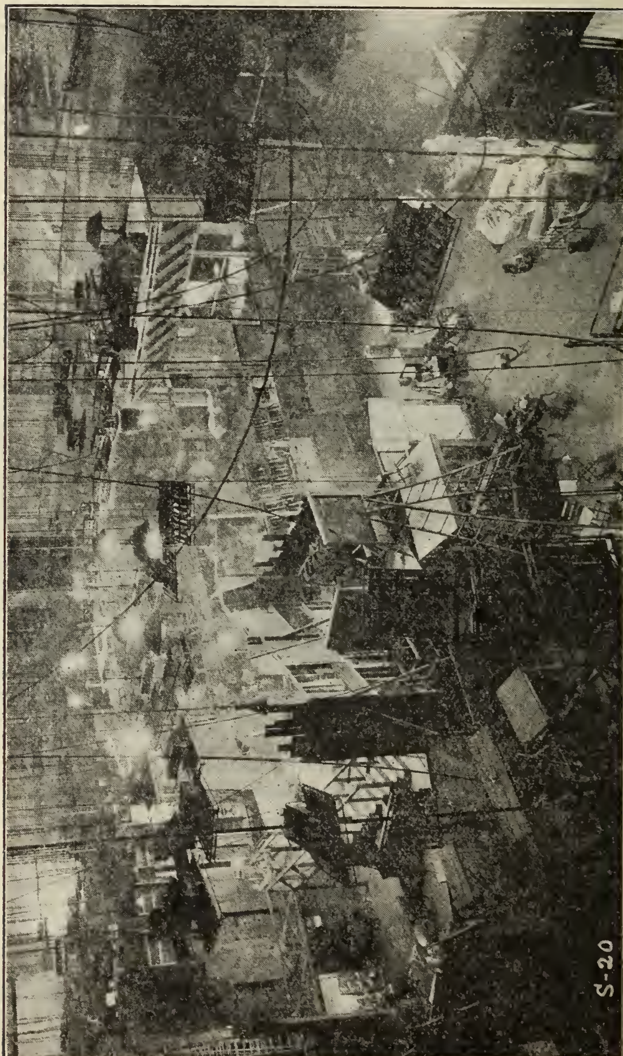


Fig. 424
View of Part of Famous Players-Lasky Studio in Operation (Long Island City, N. Y.)

The motors should properly be of the synchronous type to operate with 25% overload for a period of two hours with very little rise in temperature. A feature which cannot be emphasized too strongly is that of intermittent overload capacity in equipment used in large studios. The compensators used for starting these synchronous motors should have a special "five minute" rating for starting duty which provides additional insurance against burning them out or overheating under abnormal starting conditions. This feature is also important since these sets may at some time be started by an inexperienced operator and may require several attempts to start a machine and bring it up to synchronous speed so that it can be thrown on the line without causing a large disturbance.

HIGH CAPACITY FEEDER SYSTEM FOR DIRECT CURRENT STUDIO EQUIPMENT

On account of the large current requirements for the studio lighting equipment, a great deal of consideration should be given the feeder system intended to supply the various studio switchboards. It might be considered quite impracticable to install feeders using the conventional insulated cables in conduits, since the cables required would have to be of unusually large sizes and the conduits to protect them correspondingly large and cumbersome. The feeders to the various switchboards may be run by doubling or trebling the number of cables per leg, and with this arrangement each switchboard would be provided with a separate feeder and the total load taken off any single switchboard would be limited to the size of the individual feeder supplying it.

To avoid these conditions and to provide a feeder system of the utmost flexibility and one in which its capacity might be increased at some future time without extensive changes, a bare bus bar system can be designed having sufficient capacity to take care of all the present requirements. This consists of a single bus bar feeder which passes virtually through all the switchboards. If necessary the entire plant capacity can be taken off a single switchboard without overloading the feeder. In addition to this feature, a minimum drop in voltage is obtained and the studio is utilizing 100% of the copper installed in the building

all the time. With a separate feeder system (individual feeder to each switchboard), there may be times when as much as 90% of the copper is not in use. The bus bar feeder system is nothing more or less than an extension of the main switchboard in the generator room and is equivalent to the power plant being placed up over the studio alongside of the various studio switchboards. There are many advantages accruing from a system of this kind, some of which may be briefly stated as follows:

a. The currents handled are relatively large compared to those that can be handled by insulated cables on account of the greater amount of radiating surface exposed to the air and the facility for keeping the copper at a lower temperature for much greater current densities.

b. Due to the low operating temperature of the bus bars as compared to cables, the actual power loss in the copper is less.

c. Due to the large amount of radiating surface, the overload capacity of a bus bar feeder is greater than that of any cable having an equivalent copper cross section.

d. Due to the absence of deterioration of insulation (porcelain is used for insulation), a bus bar installation is practically permanent. The life of a cable installation may be from five to ten years, depending upon the overload demands made on the system and is dependent entirely upon the deterioration of the cable insulation.

e. Bus bar systems offer easy facilities for increasing the capacity by simply adding laminations. Cable systems require the installation of new conduits if the present conduits are too small

or else the withdrawal of present wires and the installation of heavier wires. Bus bar systems offer the advantage that they may be increased in capacity in one section of a plant with copper removed from other sections of the plant which may not be so heavily loaded. It is quite impossible to do this with cables.

f. Bus bar systems are easy to inspect and offer splendid facilities for making repairs. Cable system, when needing repair, usually requires an entire new length of cable should even a small section of it become damaged.

g. So far as the actual insulation is concerned, bus bars are better insulated than the ordinary interior rubber-covered cable, for the reason that high-voltage porcelain is used throughout and the insulation resistance of a bus bar system as shown by actual test is many times greater than that of an insulated cable system using commercial grade of insulation. The bus bars should be protected by wire grille mesh work with large air spaces between the grille work and copper work so that it is practically impossible even if the grille work is damaged to come in contact with the bus bars.

h. The cost of a high capacity bus bar system for large amounts of current usually is not much greater than that of a cable and conduit system having the same capacity, and affords all the additional advantages mentioned.

The outstanding feature of the design of this system is the fact that the studio can expand and the feeder system can also expand without any material changes to the existing system and with very little additional cost.

A characteristic of a bus bar system which

must be taken into consideration is the phenomena of mechanical forces due to magnetic effects tending to thrust the bus bars apart under short circuit conditions. Wrought iron braces and insulators should be placed every six feet. Another condition which has to be provided for is that of expansion and contraction of the copper with varying temperatures based on the worst condition in the winter when the building might not be heated to the highest temperature in the summer time. In order to provide for the expansion and contraction, the bus bars are so held in the insulators that they may slide through them without subjecting the porcelain of the insulators to any abnormal strains. The insulator bases are provided with slotted holes for expansion and it is intended that these also will assist in compensating for the expansion and contraction. Ordinarily in a system of this kind special extra flexible "U"-shaped laminated expansion joints should be installed along the line of the bus bar which function very much the same as expansion bends do on a steam line.

Figure 422 is a photograph of a bus bar feeder after the switchboards had been set in place and after the bus bars had been enclosed with wire grille. This bus bar feeder passes through five switchboards similar to the one which is in the foreground of the photograph.

IV. Studio Switchboards and Plugging Box Equipment.

Over the studio E-J Electric remote control studio switchboards similar to the one shown in Figure 423 can be installed. This photograph

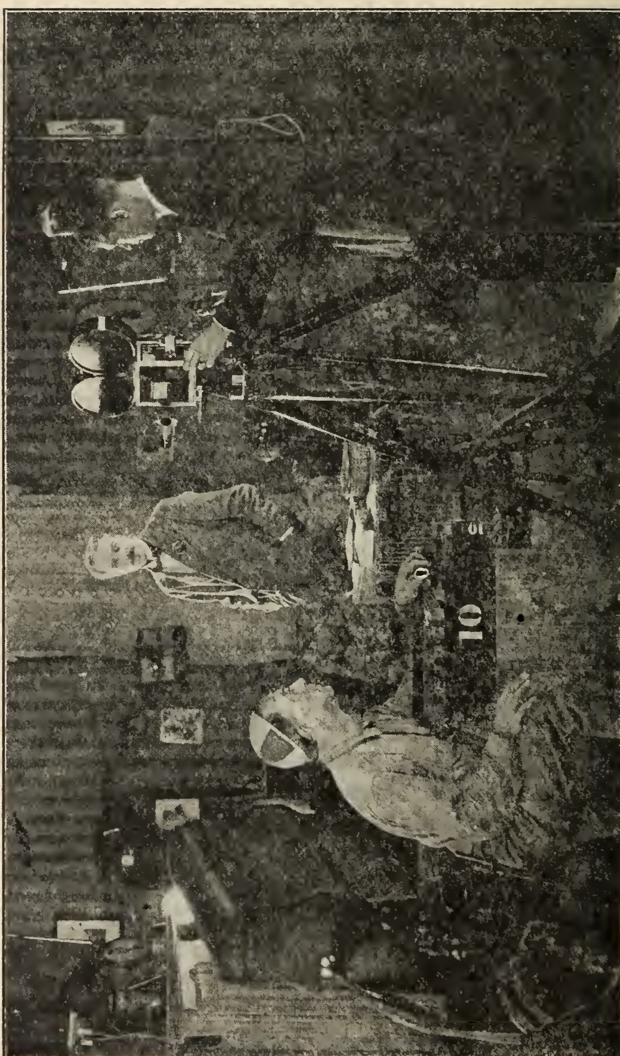


FIG. 425

"Shooting" a Small Picture, Showing Monitor Remote Control Station in Use

shows the switchboard mounted in a steel cabinet braced to a roof truss and consisting of the remote control section used for controlling the floor, lamps and top lights from a control box placed on the studio floor and a distribution section which supplies the various high capacity pockets for use with spotlights and high intensity arcs. The spotlights and arcs are usually hand-controlled at the lamp and it has, therefore, been considered inadvisable to put these on the remote control section. The advantages of the E-J Electric remote control system designed for studios over that of the old type conventional switchboard systems are many.

a. By its use, valuable floor space is not occupied by cumbersome switchboards.

b. By installing the switchboards overhead, the various stage cables may be dropped from overhead to the exact point at which they are required on the studio floor instead of having them lie across the floor interfering with stages in operation and with the moving about of scenery, floor lamps, etc. This interference is not only annoying, but actually ruins the insulation on the cables.

c. The switchboards being placed out of the way, it is impossible for anybody to touch the live parts or to be near any arcs of the switches when making and breaking circuits.

d. By its use, several stages may be worked at one time in the same studio without confusion, since the director need not shout to the operator at the switchboard controlling his stage, thereby disturbing his own and other companies which may be working, or cause delays due to misunderstandings on the part of the switchboard operator.

e. The facility for the director or camera man to operate or directly supervise at close range the lighting on his own stage without calling for an electrician and without disturbing or distracting the players' attention by shouting orders to other people.

f. The switchboard operator need not remain at the switchboard waiting for a cue to switch "on" and "off" lights. Almost any kind of special effect lighting can be controlled from the stage in combinations of one, two, three or four groups. It is also possible to arrange a switch on the "props" itself which the actor can operate so as to obtain absolute synchronism of the lights with the action of the play, eliminating thereby the time interval or lag usually noticed on the screen when the actor is supposed to turn "on" or "off" the lights in the room which he is entering or leaving.

g. To obtain lightning effects with the old type of switchboard, it was necessary for the switchboard operator to pull open and close one of the large master knife switches which not only caused considerable arcing of the switch and distracted the actor's attention, but also burned away the switch parts so that replacements or repairs were often necessary after such a scene.

With the E-J Electric Remote Control System, the director or camera man has at his command a number of keys which control the various lights or groups of lights as desired. With these operating keys, it is possible to obtain effects identical to those produced on the theatrical stage. The lights can be instantly turned off as soon as the scene is completed or while the scene is held for further instructions or rehearsal, thereby effect-

ing a considerable saving in current consumption and the trimming of arc lamps.

Each Remote Control Switchboard is equipped with six sets of Lasky type contactors. These contactors are designed to withstand a continuous overload of 100% and are provided with special magnetic blowouts so as to extinguish heavy inductive arcs on breaking the circuit.

Referring to Figure 423, the bus bar feeder is shown passing through the lower right-hand portion of the switchboard and the switchboard bus bars tapped directly into this feeder. The fuses shown over the contactors protect the various contactor circuits and when repairs or replacements are necessary on any single contactor, its fuses may be removed without interfering with the rest of the equipment on that particular switchboard. From the knife switch section of the switchboard, branch feeders are run to the various spotlight and arc pockets located over the footwalks of the studio. From each group of switchboard contactors feeders are run to plugging boxes placed directly underneath the switchboards as shown in Figure 423. Each plugging box should have capacity for six three-wire circuits arranged for connecting to six-gang portable spider boxes placed on the footwalk for the top lights or on the studio floor below for the floor lamps, and each contactor unit thereby controls all the lights connected to a six-gang spider box.

The overhead footwalks as shown in Figure 423 also holds the surplus stage cable and are used for facilitating the moving about of the overhead lighting equipment.

Figure 424 is a photograph of part of Famous Players-Lasky L. I. C. studio, showing stages set up with top lights, etc. The scene docks are shown to the right. In the foreground of this photograph is a cable dropping down from overhead to a portable Monitor station on the floor which is used by the camera man or director. The photograph does not show any stage set up at this particular point, but these cables may be dropped to any part of the floor as desired.

The Monitor Studio Remote Control Station as shown in Figure 425, specially developed for the Famous Players-Lasky Corporation and Fox Film Corporation by the E-J Electric Co., consists of a series of "break-back" switches which are thrown from one side to the other or held in a neutral center position similar to the listening keys on a telephone switchboard. These stations are ruggedly made and designed to stand all the abuse which equipment of this kind is subjected to in a studio. The pinplug connector coupling at the top permits removing the station from the portable cable so that it is unnecessary to hoist the heavy box out of the way. The left vertical key of this device is a Master which controls the left positions of all of four of the sectional keys. The left positions of the remaining two sectional keys are connected directly to the line and are not controlled by the Master. The upper right vertical key is also a master which controls the right positions of all of the sectional keys. By means of the Master keys, two large groups of lamps can be controlled in one operation and by means of the lower left positions of the two lower keys, a third group of lamps can be controlled independent of

the Masters. One of the section keys can throw "on" or "off" all the lamps connected to a single spider box usually consisting of six. The operation of one Master can throw "on" or "off" all the lamps connected to six spider boxes usually consisting of about 36 lamps. As previously stated in the design of the contactors, 100% overload capacity is provided for, and the contactors are designed not only to carry this overload without perceptible heating, and also to break the circuit without dangerous arcing or deterioration of the contact surfaces. The Monitor Remote Control Stations are also arranged with auxiliary pin plugs in the lower part, not shown in the photograph, whereby the master keys on the control station can control all the lamps corresponding to two or more other control stations with a single operation. This feature is accomplished by connecting together the various control stations by means of light portable No. 14 gauge conductors in train line fashion and this arrangement will permit the various switchboards to function in a manner similar to the Master Controller on an electric railway train consisting of several cars. The principles of the remote control system are by no means new. For the past ten years, because of the safety, simplicity, saving in time, minimizing of maintenance expense and the absence of delays due to breakdowns, it has been developed and applied to the largest industrial plants in the world where hundreds and hundreds of horsepower in motors are remotely controlled.

Fig. 425 shows the actual "shooting" of a set with the camera man to the right and his assistant operating the Monitor Remote Control Station at

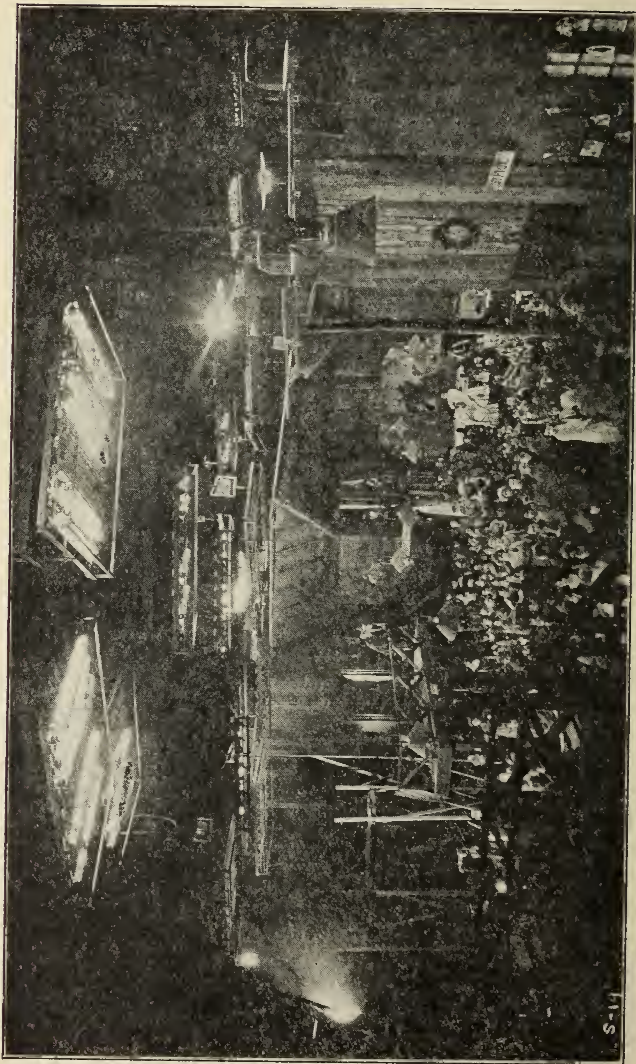


FIG. 426

"Top Lighting" of a Music Hall Scene in a Mining Camp

the left. It is clearly shown in the photograph the convenience afforded the camera man by placing the control of all lights practically at his elbow.

Fig. 426 gives an approximate idea of the use of overhead "soft" and "hard" lights in combination. The scene shown here is that of a music hall in a mining camp and it will be noted that the set is of a dark texture, but the number of players taking part is so great as to require good "hard" and "soft" lighting.

Disadvantages:

The various advantages of the overhead system are many, but there are a few disadvantages of which mention might be made at this time.

a. For studios having considerable height the cables dropping down from the footwalks are very heavy and difficult to handle unless a winding reel or special counterweight system is employed. The result is that the cables are not always lifted up and dropped to the most advantageous locations, but are partly laid on the floor.

b. Another disadvantage is the hazard connected with men working up overhead and dropping plugs, pliers or other tools through the slots in the footwalk down to the stage floor. Of course, this latter condition also exists in studios where all the connections are made up on the floor and where the men hang scenery and top lights while working on scaffolds and ladders.

An advantage of the footwalks, forming part of the overhead system, which offsets all of the disadvantages and which appeals to every studio manager, is the facility for hanging scenery ef-

fects and lights from some sort of overhead fastenings. An ideal studio would be one having its ceiling constructed of a horizontal network of steel ropes, the strands of which are capable of supporting approximately 1,000 pounds every five feet. It is a known fact that the location of the hangings for overhead equipment, including props, is always uncertain. The overhead footwalks and structural arrangement of this studio is equivalent to having the ceiling studded with eye bolts or the improvised horizontal network of steel rope. The overhead footwalks are very valuable as runways for the men to work on, but just as much so for the property men to hang their scenery and special lighting equipment.

Studio Signal Systems.

On account of the large area covered by the studio and the difficulty in summoning principals who may be on the stage floor, to the telephone or otherwise, a special electric silent call system using an electric numerical monogram signal has been devised, similar in appearance to the common carriage call used by theatres. The telephone operator is provided with a U. S. E. M. selector type keyboard, which is arranged to light up monogram signaling panels located under the footwalks in the studio and at the same time giving a single stroke on a gong, attracting attention to the illuminated signal. By means of this special selector, numbers ranging from 1 to 999 may be set up without the use of the customary perforated cards and other complicated apparatus used with carriage call systems. An outstanding feature of this Silent Call system is the fact that one does

not have to stop work to count the number of strokes on a gong in order to interpret the signal. It is merely necessary to glance up at the electric monogram to see whether or not the signal concerns one. The interference with the work on the stage is but momentary as compared to the gong and horn system used in many plants. The wiring for this system is quite simple and consists of 26 No. 14 wires and two No. 10 wires run as a single cable from the selector to the electric monograms. The current supplied is obtained from the house lighting circuits.

CURRENT REQUIRED BY MOTORS

H. P.	Direct Current Motors			Alternating Current Motors								
				Single Phase			Two Phase (4 wire)			Three Phase (3 wire)		
	110 V.	220 V.	500 V.	110 V.	220 V.	500 V.	110 V.	220 V.	500 V.	110 V.	220 V.	500 V
1	9	4.5	2.0	14	7	3.1	6.4	3.2	1.4	7.4	3.7	1.6
2	17	8.5	3.7	24	12	5.3	11	5.7	2.5	13	6.6	2.9
3	26	13	5.6	34	17	7.5	16	8.1	3.5	19	9.3	4.1
5	40	20	8.8	52	26	11	26	13	5.5	30	15	6.4
7½.....	60	30	13	74	37	16	38	19	8.1	44	22	9.3
10	76	38	17	94	47	21	44	22	10	50	25	12
15	112	56	25				66	33	15	76	38	17
20	150	75	33				88	44	19	102	51	22
30	226	113	50				134	67	29	154	77	33
40	302	151	66				178	89	39	204	107	45
50	368	184	81				204	102	45	236	118	52
75	552	276	122				308	154	68	356	178	77
100	736	368	162				408	204	90	472	236	104
150	1,110	555	244				616	308	135	710	355	156
200	1,474	737	324				818	409	180	940	470	208

This table gives the current taken, at full load, by various sizes of electric motors for direct and alternating current at the ordinary pressures of 110, 220 and 500 volts. The current taken by direct current motors depends upon the efficiency, and with alternating-current motors it also depends upon the power factor. These qualities vary somewhat in motors of different make, so the above values must be considered as fair averages. They are useful in making wiring calculations, fixing size or fuses, etc. The current given for two-phase motors is the full-load current taken in each phase; the current for the three-phase motors is the current in each of the three-line wires.

SIZE OF WIRES FOR MOTORS OF DIFFERENT HORSE POWER

DIRECT CURRENT

	110 Volts			220 Volts		
H.P.	Full-load Current	Size of Wire Mains	Size of Wire Branches	Full-load Current	Size of Wire Mains	Size of Wire Branches
1	8	14	14	4	14	14
2	15	14	12	8	14	14
3	23	10	8	12	14	14
4	30	8	6	15	14	12
5	38	6	6	19	12	10
7.5	56	5	4	28	8	8
10	75	3	1	38	6	6

SINGLE-PHASE

1	12	....	12	6	....	14
2	23	....	8	11	....	12
3	33	....	6	16	....	10
4	44	....	4	22	....	8
5	53	....	3	26	....	6

THREE-PHASE

1	....	....	....	3	14	14
2	....	....	....	5	14	14
3	....	....	....	8	14	14
4	....	....	....	10	14	14
5	....	....	....	13	14	12
7.5	....	....	....	19	12	8
10	....	....	....	26	8	6

CONVERSION TABLES

(1) Watts to Horse Power

Watts	Horse Power	Kilowatts	Horse Power
1	.0014	.5	.670
5	.0067	.75	1.005
10	.0134	1.0	1.34
20	.0268	2.0	2.68
25	.0335	3.0	4.02
30	.0402	4.0	5.36
40	.0536	5.0	6.70
50	.067	6.0	8.04
75	.100	7.0	9.38
100	.134	8.0	10.0
200	.268	9.0	12.1
250	.335	10.0	13.4

(2) Horse Power to Watts

Horse Power	Watts	Horse Power	Kilowatts
$\frac{1}{16}$	46.62	4	2.984
$\frac{1}{8}$	93.25	5	3.730
$\frac{1}{4}$	186.5	6	4.476
$\frac{1}{2}$	373.0	7	5.222
$\frac{3}{4}$	559.5	8	5.968
1	746.0	9	6.714
2	1492.0	10	7.460
3	2338.0	20	14.920

POWER REQUIRED FOR DRIVING FANS

Diameter of Blades	Power required in Watts	Approx. cub. feet of Air moved per hour	Average Speed in Revolutions per minute
12 inches	50	60,000	1,000
15 "	70	72,000	900
18 "	100	120,000	750
24 "	200	300,000	600
30 "	350	420,000	500
36 "	450	720,000	450
42 "	550	840,000	360
48 "	650	1,000,000	300

SPARKING DISTANCES IN AIR

Volts	Distance (Inches)	Volts	Distance (Inches)
5,000	.225	60,000	4.65
10,000	.47	70,000	5.85
20,000	1.00	80,000	7.1
30,000	1.625	100,000	9.6
35,000	2.00	130,000	12.95
45,000	2.95	150,000	15.00

Inches to millimetres						Centimetres to inches		
Inches		mm.		cm.		cm.		inches
$\frac{1}{16}$	=	1,58	=	0,16		1	=	$\frac{3}{8}$
$\frac{1}{8}$	=	3,17	=	0,32		2	=	$\frac{13}{16}$
$\frac{1}{4}$	=	6,35	=	0,63		3	=	$1\frac{3}{16}$
$\frac{3}{8}$	=	9,5	=	0,95		4	=	$1\frac{9}{16}$
$\frac{1}{2}$	=	12,7	=	1,27		5	=	$1\frac{31}{32}$
$\frac{5}{8}$	=	15,9	=	1,59		6	=	$2\frac{3}{8}$
$\frac{3}{4}$	=	19	=	1,9		7	=	$2\frac{3}{4}$
$\frac{7}{8}$	=	22,2	=	2,2		8	=	$3\frac{5}{32}$
1	=	25,4	=	2,54		9	=	$3\frac{9}{16}$
2	=	50,8	=	5,08		10	=	$3\frac{15}{16}$
3	=	76,2	=	7,6		11	=	$4\frac{5}{16}$
4	=	101,6	=	10,1		12	=	$4\frac{11}{16}$
5	=	127	=	12,7		13	=	$5\frac{1}{8}$
6	=	152	=	15,2		14	=	$5\frac{1}{2}$
7	=	177	=	17,7		15	=	$5\frac{15}{16}$
8	=	203	=	20,3		16	=	$6\frac{5}{16}$
9	=	229	=	22,9		17	=	$6\frac{11}{16}$
10	=	254	=	25,4		18	=	$7\frac{1}{16}$
11	=	280	=	28		19	=	$7\frac{1}{2}$
12	=	304	=	30,4		20	=	$7\frac{7}{8}$
The above values are correct to $\frac{1}{2}$ mm.						The above values are correct to $\frac{1}{32}$ in.		

TABLE OF ELECTRICAL UNITS

Name of Unit	Usually Expressed	Representing	Equivalent to
Volt	E.M.F.E.	Pressure	Ampères × Ohms
Ampère	C.; A.	Current	Volts ÷ Ohms
Ohm	R.	Resistance	Volts ÷ Ampères
Watt	W.	Power	Amp × Volt; $\frac{1}{746}$ H.P.
Kilowatt	K.W.	Power	1,000 Watts; $1\frac{1}{3}$ H.P.
Kilowatt-Hour	K.W.H.	Work	1,000 Watt-Hours
Horse Power	H.P.	Power	746 Watts
Horse Power Hour	H.P. Hour	Work	746 Watt-hours

CAPACITY OF FUSE WIRES

Dia. in 1/1,000 in.	Copper Ampères	Wires Tin Ampères	Lead Ampères
92	286.0	46.0	38.0
63	166.0	26.0	22.2
48	105.0	17.0	14.0
36	70.0	11.2	9.4
28	48.0	7.7	6.5
22	33.5	5.4	4.5
18	24.8	4.0	3.35
15	18.4	3.0	2.5
12	14.1	2.8	2.0
10	11.5	1.8	1.5
9	9.0	1.5	1.2
7	6.8	1.0	.9
6	4.7	.76	.64
4	3.5	.55	.45

REFLECTING POWER OF WALLS, PAPER, ETC.

Black Cloth.......................... 1 per cent.
Chocolate Paper...................... 5 per cent.
Dark Red............................. 12 per cent.
Dark Brown........................... 13 per cent.
Blue................................. 25 per cent.
Yellow............................... 40 per cent.
White Glazed......................... 75 per cent.

APPROXIMATE LOSS OF LIGHT DUE TO ARC LAMP GLOBES

Clear Glass.......................... 12 per cent.
Light Ground Glass................... 30 per cent.
Heavy ditto.......................... 45 per cent.
Thin Opal............................ 45 per cent.
Heavy Opal........................... 60 per cent.
Holoplane (cut glass)................ 15 per cent.

USEFUL EQUIVALENTS FOR ELECTRIC HEATING PROBLEMS

Unit.	Equivalent Values In Other Units.
1 K. W. Hour=	1,000 Watt hours 1.34 horse power hours 2,654,200 ft. lbs. 3,600,200 joules 3,412 heat units 367,000 kilogram metres .229 lbs. coal oxidized with perfect efficiency 3.53 lbs. water evaporated at 212° F. 22.75 lbs. of water raised from 62° to 212° F.
1 H. P. Hour=	.746 K. W. hour 1,930,000 ft. lbs. 2,545 heat units 273,740 k. g. m. .175 lbs. coal oxidized with perfect efficiency 2.64 lbs. water evaporated at 212° F. 17.0 lbs. water raised from 62° F. to 212° F.
1 K. W.=	1,000 Watts 1.34 H. P. 2,654,200 ft. lbs. per hour 44.24 ft. lbs. per minute 773.3 ft. lbs. per second 3,412 heat units per hour 36.9 heat units per minute 9.48 heat units per second .2275 lbs. coal oxidized per hour 2.58 lbs. water evaporated per hour at 212° F.
1 H. P.=	746 Watts .746 K. W. 33,000 ft lbs. per minute 550 ft. lbs. per second 2,545 heat units per hour 42.4 heat units per minute .707 heat units per second .175 lbs. coal oxidized per hour 2.64 lbs. water evaporated per hour at 212° F.
1 Houle Y	1 Watt second .00000278 K. W. hour .102 k. g. m. .0009477 heat units .7373 ft. lbs.

Unit.	Equivalent Valuc In Other Units.
1 ft. lb.=	1.356 joules .1383 k. g. m. .000000377 K. W. hour .0001285 heat units .0000005 H. P. hour
1 Watt=	1 joule per second .00134 H. P .001 K. W. 3.412 heat units per hour .7373 ft. lbs. per second .003 lbs. of water evaporated per hour 44.24 ft. lbs. per minute
1 Watt per Sq. In.=	8.19 thermal units per sq. ft. per minute 120° F. above surrounding air (Japanned cast iron surface) 66° C. above surrounding air (Japanned cast iron surface)
1 Heat Unit=	1055 Watt seconds 778 ft. lbs. .252 calorie (Kg. d.) 107.6 kilogram metres .000293 K. W. hour .000393 H. P. Hour .0000688 lbs. coal oxidized .001036 lbs. water evaporated at 212° F.
1 Heat Unit per Sq. Ft. per Minute=	1221 Watts per sq. inch .0176 K. W. .0296 H. P.
1 Kilogram Metre=	7.23 ¼ ft. lbs. .00000366 H. P. hour .00000272 K. W. hour .0093 heat units
1 lb. Bituminous Coal Oxidized with perfect efficiency=	14,544 heat units 1.11 lbs. Anthracite coal oxidized 2.5 lbs. dry wood oxidized 21 cu. ft. illuminating gas 4.26 K. W. hours (theoretical value) 5.71 H. P. hours (theoretical value) 11,315,000 ft. lbs. (theoretical value) 15 lbs. of water evaporated at 212° F.
1 lb. Water Evaporated 212° F.=	.283 K. W hour .379 H. P. hour 965.7 heat units 103,900 k. g. m. 1,019,000 joules 751,300 ft. lbs. .0664 lbs. of coal oxidized

RECAPITULATIONS

DEFINITIONS OF PRACTICAL ELECTRICAL UNITS

Quantities to be Measured.	Synonyms.	Symbol.	Name of Practical Unit.	Comparative Values.	REMARKS Fundamental or absolute 51 C. G. S. Units are: Centimeter (C) for Length. Gramme (G) for Mass. Second S (8) for Time.
Current.	Strength. Intensity. Rate of Flow. Coulomb per Sec. Volume (obsolete).	I	Ampere.	Coulombs ÷ Seconds. Volts÷ Ohms.	One Ampere deposits .0003286 gramme, or .004991 grain of copper per second on the plate of a copper voltmeter.
Quantity.	Ampere-Second.	Q	Coulomb.	Amperes × Seconds.	One hour=3,600 seconds. hence one ampere-hour=3,600 ampere-seconds, or=3,600 coulombs.
Electromotive Force. Difference of Potential.	Pressure Tension.	E M F or E	Volt.	Amperes × Ohms. Joules÷ Coulombs.	One volt = .933 standard Daniell cell (zinc sulphate of a density of 1.4 and copper sulphate of a density of 1.1).
Resistance.		E	Ohm.	Volts ÷ Amperes.	One legal ohm is the resistance of a column of pure mercury, 1 square millimeter in section and 106 centimeters long, at °Centigrade. 1 true ohm=1.00283 legal ohms.
Capacity.		M	Farad.	Coulombs ÷ Volts.	The microfarad, one-millionth of a farad, has been generally adopted as a practical unit. the farad is too large a unit for practical use.
Power Activity.	Electrical H. P. Rate of doing Work. Effect. Work÷Time.	P or Pw or HP	Watt. (Volt-ampere).	Volts × Amperes. (Amperes) × Ohms. (Volts) ÷ Ohms. Joules÷ Seconds.	One watt=1/746 electrical horse power. One electrical horse power $=\frac{\text{volts} \times \text{amperes}}{746}$ One electrical horse power $=\frac{(\text{amperes}) \times \text{ohms}}{746}$ One electrical horse power $=\frac{(\text{volts})}{746 \text{ ohms}}$
Work, Heat, Energy.	Power × Time.	W or Wj.	Joule (Volt-coulomb.)	Watts× Seconds. Volts× Coulombs. (Amperes) × Ohms×Seconds. (Volts)× Seconds ÷ Ohms.	One joule is the work done or heat generated by a watt in a second. One joule is the heat necessary to raise .238 gramme of water 1° C.. or one joule=.238 calorie or therm. One joule=.7375 foot-pound in a second.

EQUIVALENTS OF UNITS OF LENGTH

	Milli-meter	Centi-meter	Meter	Kilo-meter	Mil.	Inch	Foot	Yard	Mile (Stat.)	Mile (Geog.)
Millimeter.........	1	01	.001	.000001	39,37079	.039371	.003281	.001094	.0000006	.0000007
Centimeter........	.10	1	1	.00001	393.7079	.3937079	.032809	.010936	.0000062	.000007
Meter.............	1000	100	1	.001	393,7079	39.37079	3.28090	1.09363	.000621	.000716
Kilometer.........	1,000,000	100,000	1000	1		39,370.79	3280.899	1093.633	.621382	.716330
Mil...............	.025399	.0025399	.0000254		1	.001	.000083	.000028		
Inch..............	25.3994	2.53994	.025399	.0000254	1000	1	.083333	.027777	.0000158	.000015
Foot..............	304.7945	30.47945	.304795	.0003084	12000	12	1	.33333	.000189	.000101
Yard..............	914.3835	91.43835	.914384	.0009144	36000	36	3	1	.000568	.000493
Mile (Statute).....		160.931.4	1.609.314	1.609314		63,360	5280	1760	1	.868381
Mile (Geog'ph.)....		185,329	1853.29	1.85329		72,963.2	6080.27	2026.76	1.1516	1

TABLE SHOWING CARRYING CAPACITY OF WIRES: DISTANCE TO WHICH FULL LOAD MAY BE CARRIED AT 2 VOLTS DROP AND NUMBER OF LIGHTS EQUIVALENT TO FULL CURRENT GIVEN

B. & S. Gage	Rubber Insulation Ampères	Distance in Feet Causing a Loss of 2 Volts	Total Capacity in Watts		Total Number of Lamps of Different Voltages and Wattages that may be supplied											
			110 V.	220 V.	25-Watt		40-Watt		60-Watt		100-Watt		150-Watt		250-Watt	
					110 V.	220 V.	110 V.	220 V.	110 V.	220 V.	110V.	220 V.	110V.	220V.	110V.	220V.
14	15	26	1650	3300	66	132	41	82	27	54	16	33	11	22	6	13
12	20	30	2200	4400	88	176	55	110	36	73	22	29	14	29	8	17
10	25	38	2750	5500	110	220	68	137	46	91	27	55	18	36	11	22
8	35	43	3850	7700	154	308	96	192	64	128	38	77	25	51	15	30
6	50	50	5500	11000	220	440	137	275	91	183	55	110	36	73	22	44
5	55	56	6050	12110	242	484	151	302	100	201	60	121	40	80	24	48
4	70	56	7700	15400	308	616	192	385	128	256	77	154	49	99	30	61
3	80	61	8800	17600	352	704	220	440	146	292	88	176	58	117	35	70
2	90	68	9900	19800	396	792	247	494	165	330	99	198	66	132	39	78
1	100	67	11000	22000	440	880	275	550	183	366	110	220	73	146	44	88
0	125	78	13750	27500	550	1100	343	686	229	458	137	274	91	182	55	110
00	150	82	16500	33000	660	1320	412	824	275	550	165	330	110	220	66	132
000	175	89	19250	38500	770	1540	481	962	320	640	192	384	128	256	77	154
0000	225	87	24750	49500	990	1980	618	1236	412	824	247	394	165	330	99	198
200000	200	92	22000	44000	880	1760	550	1100	367	734	220	440	146	292	88	176
300000	275	104	30250	60500	1210	2420	756	1512	504	1008	302	604	201	402	121	242
400000	325	114	35750	71500	1430	2860	893	1786	596	1192	357	714	238	476	143	286
500000	400	117	44000	88000	1760	3520	1100	2200	733	1466	440	880	293	586	176	352
600000	450	123	49500	99000	1980	3960	1237	2474	825	1650	495	990	330	660	198	396
700000	500	130	55000	110000	2200	4400	1375	2750	916	1832	550	1100	366	732	220	440
800000	530	135	60500	121000	2420	4840	1512	3024	1008	2016	605	1210	403	806	242	484

A comparison of the following tables will show the superiority of using direct current from the basis of energy consumed and greater candle-power from the amperage obtained. It is regrettable that the quality of the light from direct current cannot be shown in this table of comparative results.

Comparison of candle-powers obtained from alternating and direct current-circuits with a given current consumption:

Arc ampères	Candle-power using A. C.	Candle-power using D. C.
20	624	4,900
25	894	6,220
30	1,700	8,750
40	1,830	12,000
50	4,566	16,500
60	4,650	......

WATTS CONSUMED PER HOUR FOR A GIVEN CANDLE-POWER

Candle-power	I. C. with resistance	A. C. with resistance	A. C. with economizer	A. C. with rectifier
4,000	1,900	5,800	1,700	1,300
5,000	2,250	6,900	2,200	1,500
6,000	2,600	.....	.....	1,800
7,500	3,100	.....	.....	2,250
10,000	3,800	.....	.....	2,700
12,000	4,400	.....	.....	3,200
16,500	5,500	.....	.....	3,900

VOLTS LOST ON COPPER WIRE

Table of volts lost or drop per ampere per 1,000 feet of conductor. (Calculated by $E = I \times R$. Formula (29).) Copper wire, B. & S. gauge (70° F.)

Size, B. & S.	Volts Drop per Ampère per 1,000 Ft.	Size, B. & S.	Volts Drop per Ampère per 1,000 Ft.
0000	.0493	17	5.088
000	.0621	18	6.415
00	.0783	19	8.089
0	.0987	20	10.20
1	.1242	21	12.86
2	.1570	22	16.22
3	.1980	23	20.45
4	.2496	24	25.79
5	.3148	25	32.52
6	.3970	26	41.01
7	.5006	27	51.72
8	.6312	28	65.21
9	.7958	29	82.23
10	1.040	30	103.7
11	1.266	31	130.7
12	1.696	32	164.9
13	2.012	33	207.9
14	2.537	34	262.2
15	3.200	35	330.6
16	4.035	36	416.8

TABLE OF RESISTIVITIES AND CONDUCTIVITIES OF METALS

Substances	Specific Resistance in Microhms Per Cubic Centimeter	Relative Conductivity at Zero, Centigrade
Pure Silver	1.49	100.00
Refined Copper	1.59	99.90
Pure Gold (unalloyed)	2.04	86.65
Aluminum (annealed)	2.89	63.09
Swedish Iron	10.08	16.00
Platinum (pure)	11.00	10.60
Lead	19.63	8.88
German Silver	30.00	7.70
Mercury	94.30	1.60

TABLE OF BRIGHTNESS VALUES IN CANDLE-POWER PER SQUARE INCH

White paper in bright sunlight	15
Coal gas flame	3
Kerosene flame	0.9
Acetylene flame	30.60
Welsbach mantle (mean)	30
Carbon filament	750
Tungsten filament (ordinary vacuum practice)	1,000
Tungsten filament (ordinary gas-filled practice)	2,000–7,000
Nearest lamp glower (max.)	3,000
Lime light	2,000
Tungsten filament (special practice))	24,000
The sun at mid-day	660,000

LAWS AND REGULATIONS GOVERNING THE SHOWING OF MOTION PICTURES

NEW YORK

Penal Law.

Con. Law; Ch. 40.

§ 484; Sub. 1.—Any person who admits to or allows to remain in any kinetoscope or moving picture performance owned, leased, managed or controlled by him or by his employer, or where such person is employed or performs such service as door keeper or ticket seller or ticket collector, any child actually or apparently under the age of sixteen years, unless accompanied by its parent or guardian, or unless such kinetoscope or moving picture exhibition is given under the auspices or for the benefit of any school or church or educational or religious institution not operated for profit, is guilty of a misdemeanor.

Penal Law.

Con. Law; Ch. 40.

§ 485. Certain employment of children under the age of sixteen years prohibited.

Sub. 5 (as amended by Law 1916; Ch. 278).

But this section does not apply to the employment of any child in posing or acting, or as a subject for use, in or for, or in connection with, the making of a motion picture film with the written consent of the mayor of the city, or the president of the board of trustees of the village where such concert or exhibition takes place. Such consent shall not be given unless 48 hours previous notice of the application shall have been served in writing upon the society mentioned in section 491 of this chapter (Society for Prevention of Cruelty to Children), if there be one within the county, and a hearing had thereon if requested and shall be revocable at the will of the authority giving it. It shall specify the name of the child, its age, the names and residence of its parents or guardians, the nature, time, duration and number of performances permitted, together with the place and character of the exhibition; and where any child is to be employed in the making of a motion pic-

ture film it shall provide that the child is to be employed only in the manner described and set forth in the statement in writing submitted with the application as hereinafter provided. Any person applying for such consent for the use or employment of any such child or children in any place in the State, in posing or acting for or as a subject for use in or in connection with the making of a motion picture film shall submit with such application a true and accurate statement in writing setting forth and describing in detail the entire part to be taken and each and every act and thing to be done and performed by such child in the making of such film, to the local official having authority to issue such permits or of any such society having jurisdiction in such place. But no such consent shall be deemed to authorize any violation of the first, second, fourth or fifth subdivision of this section.

Laws 1913; Ch. 308.

(Being Con. Laws, Ch. 20, Article 12a. Gen. Bus. Law.)

§ 209. No cinematograph or any other apparatus for projecting moving pictures save as expected in §§ 211 and 213 of this article which apparatus uses combustible films of more than 10 inches in length, shall be set up for use or used in any building, place of public assemblage, for entertainment, unless such apparatus for the projecting of moving picture shall be inclosed therein in a booth or enclosure constructed of concrete, brick, hollow tile or other approved fireproof framework covered or lined with asbestos board or with some other approved fire resisting material, and unless such booth shall have been constructed as provided in § 210 of this article and the certificate provided in § 212 of this article shall have been issued to the owner or lessee of the premises wherein such booth is situated.

§ 210. The booth provided for in § 209 of this article shall be constructed according to plans and specifications which shall have been first approved, in a city, by the mayor or chief executive officer of the city department having supervision of the erection of buildings in such city; in a village, by the president of such village; in a town outside the boundaries of a city or village, by the supervisor of such town. Provided, however, that no plans and specifications for the construction of such booths shall be approved by any public official, unless the following requirements are substantially provided for in such plans and specifications.

1. Dimensions.—Such booths shall be at least 6 feet in height. If one machine is to be operated in such booth

the floor space shall be not less than 48 square feet. If more than one machine is to be operated therein, an additional 24 square feet shall be provided for each additional machine.

2. General Specifications.—In case such booth is not constructed of concrete, brick, hollow tile or other approved fireproof material than asbestos, such booth shall be constructed with an angle framework of approved fireproof material, the angles to be not less than 1¼ inches by 3/16 of an inch thick, the adjacent members being joined firmly with angle plates of metal. The angle members of the framework shall be spaced not more than 4 feet apart on the sides and not more than 3 feet apart on the front and back and top of such booth. The sheets of asbestos board or other approved fire resisting material shall be at least ¼ of an inch in thickness and shall be securely attached to the framework by means of metal bolts and rivets. The fire resisting material shall completely cover the sides, top and all joints of such booth. The floor space occupied by the booth shall be covered with fire resisting material not less than ⅜ of an inch in thickness. The booth shall be insulated so that it will not conduct electricity to any other portion of the building. There shall be provided for the booth a door not less than 2 feet wide and 5 feet 10 inches high, consisting of an angle frame of approved fireproof material covered with sheets of approved fireproof material ¼ of an inch thick and attached to the framework of the booth by hinges, in such manner that the door shall be kept closed at all times, when not used for ingress or egress.

The operating windows, one for each machine to be operated therein and one for the operator thereof, shall be no larger than reasonably necessary to secure the desired service, and shutters of approved fireproof material shall be provided for each window. When the windows are open, the shutters shall be so suspended and arranged that they will automatically close the window openings, upon the operating of some suitable fusible or mechanical releasing device.

Where a booth is so built that it may be constructed to open directly on the outside of the building through a window, such window shall be permitted for the comfort of the operator, but such booth shall not be exempted from the requirement of the installation of a vent flue as hereinafter prescribed. Said booth shall contain an approved fireproof box for the storage of films not on the projecting machine. Films shall not be stored in any other place on the premises; they shall be rewound and repaired either

in the booth or in some other fireproof enclosure. The booth in which the picture machine is operated shall be provided with an opening or vent flue in its roof or upper part of its side wall leading to the outdoor air. The vent flue shall have a minimum cross-sectional area of 50 square inches and shall be fireproof. When the booth is in use there shall be a constant current of air passing outward through said opening or vent flue at the rate of not less than 30 cubic feet per minute.

§ 211. Sections 209 and 210 of this article shall not be retroactive for any booth approved by the appropriate public authority or official prior to this article taking effect, provided such booth have or be so reconstructed of the same material as to have dimensions as specified in section 210 of this article; provided such booth conform to the specifications of section 210 as regards vent flue, box for storage of films, specifications for rewinding and repairing films and specifications for windows and doors, and provided such booth be of rigid fireproof material, and be insulated so as not to conduct electricity to any other part of the building and be so separated from any adjacent combustible material as not to communicate fire through intense heat in case of combustion within the booth.

§ 212. After the construction of such booth shall have been completed, the public officer charged herein with the duty of passing upon the plans and specifications therefor shall within 3 days after receipt of notice in writing that such booth has been completed cause such booth to be inspected. If the provisions of sections 209 and 210 of this article have been complied with, such public officer shall issue to the owner or lessee of the premises wherein such booth is situated a certificate stating that the provisions of sections 209 and 210 of this article have been complied with.

§ 213. Where motion pictures are exhibited daily for not more than one month, or not oftener than 3 times a week, in educational or religious institutions, or bona fide social, scientific, political or athletic clubs, a portable booth may be substituted for the booth required in sections 209 and 210 of this article. Such booth shall have a height of not less than 6 feet and an area of not less than 20 square feet and shall be constructed of asbestos board, sheet steel of no less gauge than 24, or some other approved fireproof material. Such portable booth shall conform to the specifications of section 210 of this article with reference to windows and door, but not with reference to vent flues. The floor of such booth shall be elevated above the perma-

nent support on which it is placed by a space of at least ½ inch, sufficient to allow the passage of air between the floor of the booth and the platform on which the booth rests, and the booth shall be insulated so that it will not conduct electricity to any other portion of the building.

§ 214. (As amended by Laws 1916; Ch. 185).

The above sections 209, 210, 211, 212 and 213, referring to permanent and portable booths, shall not apply (a) to any miniature motion picture machine in which the maximum electric current used for the light shall be 350 watts. Such miniature machine shall be operated in an approved box of fireproof material constructed with a fusible link or other approved releasing device to close instantaneously and completely in case of combustion within the box. The light in said miniature machine shall be completely enclosed in a metal lantern box covered with an unremovable roof. (b) To the use or operation of any so-called miniature motion picture apparatus which uses only an enclosed incandescent electric lamp and approved acetate of cellulose or slow burning films, and is of such construction that films ordinarily used on full-sized commercial picture apparatus cannot be used therewith.

§ 215. Before moving pictures shall be exhibited with a portable booth under section 213 of this article, and before a miniature machine without a booth shall be used as prescribed in section 214 of this article, there shall be obtained from the appropriate authority, as defined in section 210 of this article, a certificate of approval.

§ 216. The violation of any of the provisions of this article shall constitute a misdemeanor. This act shall not apply to cities which have local laws or ordinances now in force which provide for fireproof booths of any kind for moving picture machines or apparatus.

Laws 1916; Ch. 184.

(Being Con. Laws. Ch. 21, § 18 and § 18a. Gen. City Law.)

§ 18. It shall not be lawful for any person or persons, save as excepted in section 18a of this article, to operate any moving picture apparatus and its connections in a city of the first class unless such person or persons so operating such apparatus is duly licensed as hereinafter provided. Any person desiring to act as such operator shall make application for a license to so act to the mayor or licensing authority, designated by the mayor, unless the charter of said city so designates, which officer shall furnish to each applicant blank forms of application which the applicant shall fill out. Such officer shall make rules

and regulations governing the examination of applicants and the issuance of licenses and certificates. The applicant shall be given a practical examination under the direction of the officer required to issue such license and if found competent as to his ability to operate moving picture apparatus and its connections shall receive within 6 days after such examination a license as herein provided. Such license may be revoked or suspended at any time by the officer issuing the same. Every license shall continue in force for one year from the date of issue unless sooner revoked or suspended. Every license unless revoked or suspended, as herein provided, may at the end of one year from the date of issue thereof be renewed by the officer issuing it in his discretion upon application and with or without further examination as he may direct. Every application for renewal of license must be made within the 30 days previous to the expiration of such license. With every license granted there shall be issued to every person obtaining such license a certificate, certifying that the person named therein is duly authorized to operate moving picture apparatus and its connections. Such certificate shall be displayed in a conspicuous place in the room where the person to whom it is issued operates moving picture apparatus and its connections. No person shall be eligible to procure a license unless he shall be of full age. Any person offending against the provisions of this section, as well as any person who employs or permits a person not licensed as herein provided to operate moving picture apparatus and its connections, shall be guilty of a misdemeanor and upon conviction thereof shall be punished by a fine not exceeding the sum of $100, or imprisonment for a period not exceeding 3 months, or both.

§ 18a. Nothing contained in § 18 shall be considered to apply to any so-called miniature motion picture apparatus which uses only on enclosed incandescent electric lamp and approved acetate of cellulose or slow burning films, and is of such construction that films ordinarily used on full sized commercial picture apparatus cannot be used therewith.

Laws 1916; Ch. 622.

(Being an amendment to Workmen's Compensation Law. Con. Law, Ch. 67, § 2, group 40.)

§ 2. Compensation provided for in this chapter shall be payable for injuries sustained or death incurred by employees engaged in the following hazardous employments:

Group 40.—Manufacture of moving picture machines and films.

NEW JERSEY

All lights used in theatres shall be properly protected by globes or glass coverings, or in such other manner as the board or body having control of the extinguishment of fires in any city shall prescribe; the owners or managers or the persons having charge thereof, shall provide, such means of communicating alarms of fire, accident or danger to the police and fire departments respectively, and shall also provide such fire hose, fire extinguishers, buckets, fire hooks, axes, fire doors and other means of preventing and extinguishing fires as the body or board having control of the extinguishment of fire shall direct; no obstruction or any article or thing whatever shall be placed in any aisle or passageway in any such theatre.

The board or body having control of the extinguishment of fires may detail not to exceed two members of its force at each and every place of public amusement where machinery and scenery are used while such place is open to the public, whose duty it shall be to guard against fire, and who shall have charge and control of the means provided for its extinguishment and shall have the direction and control of the employees of the place to which they may be detailed, for the purpose of extinguishment of any fire which may occur therein.

Any person or corporation who shall wilfully violate, or neglect or refuse to comply with any provision or requirements of this act, or any regulation, order or special direction duly made thereunder, shall for every such offense, pay to the city in which such offense shall be committed, a penalty of not less than fifty, nor more than two hundred dollars in the direction of the judge or court, which penalty may be recovered in any court now or hereafter provided for the enforcement of the ordinance of such city, and for the collection of penalties for the violations thereof, and it shall be the duty of the board or body having the control of the extinguishment of fires in such city to enforce the provisions of this act, and to arrest any person or persons who shall violate the provisions of this act, or any regulation, order or special direction duly made thereunder.

Laws 1912; Ch. 197.

§ 1. It shall be unlawful to use or to set for use any cinematograph or other apparatus or machine for projecting or exhibiting moving pictures, when such apparatus or machine uses films of a combustible material more than ten inches in length, in any building, place of public assem-

blage or entertainment, unless such apparatus or machine be enclosed in a booth or other enclosure covered or lined with asbestos or other strong and fire-resisting material that will withstand, on a twelve inch square sample at least a centre load of at least 250 pounds, and which shall be sufficient to resist a temperature of at least 1500 degrees Fahrenheit for at least thirty minutes, and after which being immersed in water, will not lose more than fifty per centum of its initial strength.

§ 2. The booths provided for in the last section of this act shall be at least seven feet in height, inside dimensions; if for the use of one such machine or apparatus as is mentioned in the last section, the area occupied by such booth shall not be less than 48 square feet; if more than one such machine or apparatus is to be operated therein, an additional 24 square feet of area shall be provided. Such booth shall be constructed with a framework of iron angles not less than 1¼ inches by 1¼ inches by 3/16 of an inch thick. The adjacent iron members being firmly joined with angle plate or iron; the iron members of the framework shall be spaced not more than 4 feet apart. The fire material herein mentioned shall completely cover the sides and top; all joints of such booth and framework shall be pointed up with asbestos retort cement; the sheets of such fire resisting material shall be at least ¼ of an inch in thickness, and shall be securely attached to the iron framework by means of iron bolts and rivets. The floor of such booth shall be covered with such fire resisting material not less than ⅜ of an inch in thickness. For each booth there shall be provided a door not less than two feet in width and six feet in height, consisting of an angle iron frame covered with sheets of said fire resisting material ¼ of an inch in thickness, and attached to the framework of such booth by hinges, in such manner that the door shall be kept closed automatically at all times, when not used for ingress or egress. The windows in such booth used in connection with the machines and apparatus, and by the operators thereof, shall not be larger than is reasonably necessary to secure the desired service, and such fire resisting material shall be provided for each window and shall be so suspended and arranged that they will automatically close the window openings upon the operation of either a fusible or mechanical releasing device, with a fusible link attached, also booth to be provided with an opening for ventilation, this opening to be provided with an automatically closing door or a riveted conductor pipe to outside of building or into chimney.

§ 3. No booth of the character above mentioned shall be constructed until plans and specifications therefor have been submitted to and approved by the executive officer of the municipality wherein such booth is to be constructed, having in charge the department relating to the erection of buildings, or in municipalities where no such department exists by the executive officer or body in charge of the fire department thereof; no plans or specifications shall be approved which do not conform to the minimum requirements set forth in the last preceding section hereof.

§ 4. Every such certificate of approval shall expire in 60 days after its date, and no booth shall be erected under such certificate of approval unless the same be erected within 60 days from the date of such approval.

§ 5. After any booth shall have been constructed in accordance with the terms of this act, the owner of the premises wherein the same is to be located, or the lessee thereof, or the person for whom such booth is being constructed, shall notify the proper officer or body provided in this act, of the fact of the completion of such construction, within five days after such completion. Thereupon such officer or body shall cause such booth to be inspected, and if found to have been constructed in accordance with the plans and specifications, and with the requirements of this act, and in such manner as to render safe the operation of the apparatus or machines intended to be used therein for the purpose of projecting moving pictures, such officer or body shall issue to the owner, lessee or other person above mentioned, a certificate to that effect. Such certificate shall be posted in such public part of such booth as to enable the same to be distinctly seen from a point in such building or place of assemblage at least five feet distant from such booth.

§ 6. The board or body having charge of the supervision and control of the erection of buildings in any municipality shall prescribe the details for the submission of plans and specifications and their approval, the inspection of such booth and their approval and the issuance of certificates under this act, and shall fix the fees to be paid for such certificates and inspection.

§ 7. For a violation of any of the provisions of this act the person so offending shall be fined the sum of $50; on complaint and proof of such violation before any police justice, recorder, justice of the peace or other magistrate in municipalities where the office of police justice or recorder does not exist; and such penalty shall be inflicted for each day such violation may be persisted in. Such

penalty may be exacted against the owner or lessee of the premises wherein such violation occurs, or both.

§ 8. This act shall take effect immediately and all acts and parts of acts inconsistent with the provisions hereof are hereby repealed.

Laws 1914; Ch. 190.

(Being a Supplement to Laws 1912; Ch. 197.)

§ 1. The act to which this act is a supplement shall not apply to moving picture machines using only cellulose acetate films not more than 100 feet in length nor more than one inch in width and not requiring more than 500 watts of electric current to operate the arc, except when such machines are used or exhibited in theatres or public places of entertainment, regularly used as such, to which admission fees are charged.

Laws 1913; Ch. 122.

(Being a Supplement of the "City Commission Act" Law of 1911; Ch. 221.)

§ 1. In order to lessen the dangers caused by fire, explosion and panic, the board of commissioners shall have power to regulate the use of dance halls, schools, churches, opera houses, and all buildings used for public entertainment or amusement; to compel the owners, lessees, or persons operating or controlling the same to provide adequate and sufficient exits and fire escapes therefrom, and to prevent the obstruction thereof; to properly guard all lights and electric wires therein; to regulate the construction, installation and use of moving picture machines, scenery and other apparatus used in such buildings.

Laws 1916; Ch. 276.

§ 1. A portable booth may be used for temporary one night exhibitions of moving pictures in places of public assemblage in such halls and buildings as are used by commercial and fraternal organizations, churches, schools, and civic societies and social clubs where by reason of the temporary nature of the entertainment it is deemed impracticable to install a permanent booth; provided, however, that no portable booth shall be used or permitted where entertainments last over three nights in succession.

§ 2. Such portable booth shall conform strictly to the following specifications: Each portable booth shall be at least 6 feet in height, inside measurements. If for the use of one picture machine, the area occupied by such ma-

chine shall be not less than 20 square feet, and 20 additional square feet for each additional picture machine to be operated therein; such portable booth shall be constructed with the framework of angle iron not less than 1¼ inches by 1¼ inches and 3/16 of an inch thick; the iron members of such framework shall be spaced not more than 4 feet apart on the sides, and not more than 3 feet apart on the front, back and top of such portable booth, and shall be enclosed and completely covered on all sides, top and bottom, with either twenty-four gauge steel plate or one-quarter inch asbestos boards, excepting that if the bottom is covered by asbestos boards said boards shall be at least ⅜ of an inch thick. The floor of such portable booth shall be elevated above the permanent support on which it is placed by a space of at least ½ inch. Each portable booth shall be provided with self-closing doors not less than two feet in width and 5 feet and 10 inches in height, consisting of an angle iron frame covered with either 24 gauge steel plate or one-quarter inch asbestos board, and attached to the framework of such portable booth by hinges, in such manner that the door shall be kept closed automatically at all times, when not used for ingress or egress. The windows in such portable booth used in connection with the machines and apparatus, and by the operators thereof, shall not be larger than is reasonably necessary to secure the desired service. Twenty-four gauge steel plate or ¼ inch asbestos board shall be provided for each window, and shall be suspended and arranged that they will automatically close the window openings upon the operation of either a fusible or mechanical releasing device, with a fusible link attached; and so far as possible the construction of said portable booth must meet the requirements and specifications for a permanent booth. Such portable booth may be constructed of a folding type, but in such case it must be constructed in such manner that when it is assembled for use it will be rigid with all its joints tight.

Laws 1911; Ch. 143.

§ 2. Any person having the management or control of any theatre or place wherein theatrical, acrobatic or vaudeville performances are given by paid performers, or wherein any moving picture show is given, his agents or servants, who shall admit thereto, or permit or suffer to remain therein any child under the age of sixteen years, unaccompanied by a parent, guardian or adult friend, shall be guilty of a misdemeanor and punished by a fine not exceeding one hundred dollars.

Supplement to "An Act relating to regulating and providing for the government of cities." Laws 1902; Ch. 107.

Laws 1912; Ch. 331.

§ 1. Every city of this state which has adopted or which may hereafter adopt the act to which this is a supplement shall have power by ordinance to provide regulations for operating cinematographs or moving picture machines and other similar apparatus, involving the use of a combustible film more than 10 inches in length, and any such city shall have power by ordinance to provide for and require examination by such official of said city "as the governing body thereof shall select" of any and all persons over eighteen years of age desiring to act as operators of such machines and to authorize such official to issue a license annually to such person or persons as shall successfully pass an examination conducted under rules and regulations to be approved by the governing body of any such city. Such ordinance may provide for a fee to be paid by every person to whom a license or renewal shall be issued and a penalty for operating any such machines without having such license therefore and for violation of other terms and provisions of such ordinance, in any amount not exceeding $50 for each offense or imprisonment not exceeding 30 days in default of the payment of such fine.

Laws 1917; Ch. 134.

§ 1. No licensed operator or booth shall be required for any motion picture exhibition in which the apparatus for projecting such motion pictures uses only an enclosed incandescent lamp; and only cellulose acetate or other slow burning films of a size or perforation differing from the standard as used in regularly licensed theatres, moving picture theatres or similar establishments, providing such exhibition is approved by the municipal authorities having jurisdiction.

Laws 1914; Ch. 112.

§ 1. No operator's license shall be required to operate any cinematograph or moving picture machine or other similar apparatus involving the use of a film more than 10 inches in length when such apparatus or machine uses only cellulose acetate films, or other non-explosive films not more than 100 feet in length nor more than one inch in width and does not require more than 500 watts of electric current to operate the arc.

MASSACHUSETTS

Acts 1914; Ch. 791.

§ 1. No cinematograph, or similar apparatus, involving the use of a combustible film more than ten inches in length, shall be kept or used for the purpose of exhibiting such films in or upon the premises of a public building, public or private institution, schoolhouse, church, theatre, special hall, public hall, miscellaneous hall, place of assemblage, or place of public resort, until such cinematograph or similar apparatus has been inspected and approved by an inspector of the building inspection department of the district police, who shall have placed thereon a numbered metal tag; nor until a booth, or enclosure, which has been inspected and approved by such an inspector and his certificate issued therefor, has been provided for said apparatus; nor until such precautions against fire as the chief of the district police may specify have been taken by the owner, user or exhibitor therefor; provided, however, that no such cinematograph or similar apparatus shall be operated with oxyhydrogen gas, so-called, or with limelight. In addition, in the city of Boston, the location of any booth or enclosure surrounding said apparatus, shall be approved by the building commissioner, who may order such additional precautions against fire as he may deem necessary.

§ 2. The inspectors of the building inspection department of the district police are hereby empowered and directed to inspect any cinematograph or similar apparatus involving the use of a combustible film more than ten inches in length, which is to be kept or used in or upon any of the premises defined in section 1 of this act; and also to inspect any booth or enclosure provided for the same; and the chief of the district police shall make such rules and regulations as he may deem necessary for the safe use thereof.

§ 3. For the inspection of a cinematograph or similar apparatus, or for the inspection of a booth or enclosure, as provided by section 1 of this act, a fee of two dollars shall be paid by the owner or user thereof.

§ 4. Except as provided for in section 6 of this act, no person shall exhibit or operate any cinematograph or similar apparatus involving the use of a combustible film more than ten inches in length, in or upon any of the premises defined in section 1 of this act, until he has received a special or first-class license so to do from an inspector of the building inspection department of the district police. No such license shall be granted until the

applicant has passed an examination proving him to be thoroughly skilled in the working of the mechanical and electrical apparatus or devices used in, or connected with, the operation of a cinematograph or similar apparatus, as hereinbefore defined, and no person under twenty-one years of age shall be eligible for such examination. The fee for the examination shall be three dollars and shall accompany the application for license. The first-class license shall be for the term of one year from the date thereof, but may be renewed yearly without examination, by an inspector of the building inspection department of the district police, upon the payment of a fee of one dollar.

§ 5. Any person eighteen years of age or over, desiring to act as an assistant to a holder of a special or first-class license, shall register his name, age and address on a form furnished for the purpose by the chief of the district police; and, upon the payment of a fee of one dollar, the said chief may issue a permit allowing such person to assist such a licensed operator in a booth or enclosure; but such person shall not himself operate the cinematograph or similar apparatus. The permit shall be for the term of one year from the date thereof, but may be renewed yearly by the chief of the district police upon the payment of a fee of fifty cents.

§ 6. A second-class license giving the right to operate a hand-driven cinematograph or similar apparatus, but only in the presence of a holder of a special or first-class license, may be granted to any person who is not less than twenty years of age and who has been employed for three months as an assistant under the supervision of a licensee or licensees in or upon any of the premises defined in section 1 of this act. The applicant, as a condition of receiving the said second-class license, shall pass an examination satisfactory to an inspector of the building inspection department of the district police, and shall present to the chief of the district police an affidavit signed and sworn to by him, stating that he has so worked for said period. The chief of the district police may require that the affidavit be corroborated. The fee for the examination shall be two dollars and shall accompany the application for license. The license shall be for the term of one year from the date thereof, but may be renewed yearly by an inspector of the building inspection department of the district police upon the payment of a fee of fifty cents.

§ 7. Any person over twenty-one years of age who has held a second-class license for three months or more and has worked regularly during that period in a booth or en-

closure in or upon any of the premises defined in section 1 of this act, may receive a license of the first class upon presenting to the chief of the district police an affidavit signed and sworn to by him stating that he has so worked for the said period and upon passing the examination and payment of the fee as provided for in section 4 of this act.

§ 8. Any person who has operated a cinematograph or similar apparatus under a license issued by the district police under any preceding act and any person over twenty-one years of age who presents to the chief of the district police an affidavit signed and sworn to by him stating that he has operated a cinematograph or similar apparatus in a booth or enclosure, in a theatre or hall devoted to public exhibitions of moving pictures outside the commonwealth for a period of three months or more shall be eligible for the examination for a special or a first-class license as provided in sections 4 and 10 of this act.

§ 9. A first-class license shall apply only to the operation of a hand-driven cinematograph or similar apparatus.

§ 10. The holder of a first-class license as defined in this act, or any person designated in section 8 of this act who passes an examination satisfactory to the district police, may be granted a special license to operate by hand or by motor any cinematograph or similar apparatus which has been inspected and tagged by the district police. The fee for the examination shall be three dollars and shall accompany the application for a license. The license shall be for the term of one year from the date thereof, but may be renewed yearly by an inspector of the building inspection department of the district police upon the payment of a fee of one dollar.

§ 11. An operator's license or an assistant's permit issued under this act may be suspended or revoked for cause at any time by an inspector of the building inspection department of the district police, but the person whose license or permit is so suspended or revoked may appeal to the chief of the district police, whose decision in the matter shall be final.

§ 12. Except in the city of Boston, the chief of the district police may grant permits for the special exhibition of pictures by the use of a cinematograph or similar apparatus in or upon any of the premises defined in section 1 of this act, which, in his opinion, are in safe condition for such exhibitions, and he may prescribe such regulations as he may deem necessary for the presentation of the same. A fee of two dollars shall accompany the application for each permit.

§ 13. The provisions of sections 1 to 5, inclusive, of this act, shall not apply to any cinematograph or similar apparatus operated with only cellulose acetate films not more than one inch and one-fourth in width and requiring not more than five hundred watts of electric current to operate the arc; provided, however, that such machines shall not be kept or used in or upon any of the premises defined in section 1 of this act except under such regulations as the chief of the district police shall prescribe.

§ 14. This act shall not apply to licenses or special licenses to operate cinematographs or similar apparatus issued by the district police and now in force, but upon the expiration of any such licenses the holder of a special license shall be entitled to a special license under this act upon the payment of the renewal fee as provided for in section 10, and the holder of a license shall be entitled to a first-class license under this act upon the payment of the renewal fee as provided in section 4 of this act.

§ 15. Any person, firm, corporation or association of persons, keeping or using a cinematograph or similar apparatus contrary to the provisions hereof, or in violation of any rule or regulation made by the chief of the district police, or, in the city of Boston, in violation of any regulation or requirement made by the building commissioner in accordance with the provisions hereof, shall be punished by a fine of not less than fifty nor more than five hundred dollars.

§ 16. Chapters five hundred and sixty-five and five hundred and sixty-six of the acts of the year nineteen hundred and eight; chapter two hundred and eighty-one of the acts of the year nineteen hundred and nine; chapters forty-eight and four hundred and forty of the acts of the year nineteen hundred and eleven; chapter one hundred and eighty-two of the acts of the year nineteen hundred and twelve, and all acts and parts of acts inconsistent herewith are hereby repealed.

§ 17. Notwithstanding any of the provisions of this act, the chief of the district police may grant special licenses for operators of moving pictures in churches, schoolhouses, or public institutions in the cities and towns of the commonwealth, except Boston, which, in his opinion, are in safe condition for said exhibitions, and he may prescribe regulations for the proper conduct of the same. A fee of two dollars shall accompany each application for such special license. (Approved July 7, 1914.)

COMMONWEALTH OF PENNSYLVANIA

Moving Picture Act of May 1, 1909

Section 1. That it shall be unlawful for any person, firm, association, or corporation to erect, set up, construct, maintain, or use any permanent booth or enclosure for the purpose of operating therein moving picture machines, unless they are built, erected and constructed as follows:

Size: All permanent booths or enclosures to be at least seven feet high, the floor space to vary according to the number of machines in booths or enclosures, as follows:

One picture machine, six feet by eight feet.

One picture machine and one stereopticon, nine feet by eight feet.

Two picture machines and one stereopticon, twelve feet by eight feet.

The same to be made of structural steel as follows:

Four outside horizontal members at top and bottom.

Four corner uprights and members supporting roof, to be made of one and one-half inch by one and one-half by one-fourth inch angle-irons.

Intermediate uprights to be spaced every two feet, and to be made of either one and one-half inch by one and one-half inch by one-fourth inch angle-irons or two inch by two inch by one-fourth inch tee-irons.

Tee-irons, to which roof is attached, to be made of one and one-half inch by one and one-half inch by three-sixteenth inch tee-irons.

All joints to be made with a three-sixteenth inch steel plate, to which each angle-iron or tee-iron shall be riveted or bolted by the use of at least (2) one-fourth inch bolts or rivets.

All bolts or rivets in frame to have flat heads, said heads always to be placed on exterior side of booth; all angle or tee-irons being so countersunk as to accomplish this result.

Frame to be built with a six-foot by two-foot doorway; frame of said doorway to be built of one inch by one inch by three-sixteenth inch angle-irons, which are to be joined together by the use of a three-sixteenth inch steel plate.

Covering of Booth: Sides and top of booth to be covered with asbestos boards of at least one-fourth inch in thickness; said boards to be cut and arranged that vertical joints between boards shall always come over an angle or tee-iron, so that both boards may be securely fastened to the same.

After booth is complete, all openings where combustible material is exposed must be plugged with asbestos cement,

or other equally satisfactory material. When joints of asbestos boards, on outside of booth, do not come over angles of tee-irons, the cracks between the boards shall be covered by a strip of asbestos board at least one-eighth inch thick and two inches wide; said strips to be securely fastened to both boards in such manner as to cover the exposed points. The above-mentioned strips and all asbestos boards shall be secured in the proper place by the means of proper bolts and nuts; said bolts and nuts to be spaced not more than six inches apart.

Flooring: Floor shall be made of two parts, an upper and a lower floor. Lower floor shall be made of boards seven-eighth inch minimum thickness, supported on lower leg of horizontal angle-irons. Resting on this floor shall be a floor made of asbestos boards of three-eighth inch minimum thickness, or an equally good material.

Windows: There shall not be more than two windows per machine in the booth—one for the operator and one for the machine. Window for machine shall not be more than six inches high and twelve inches long, and shall be located and cut after machine is set up. Operator's window shall not be more than four inches wide or more than twelve inches high.

All windows shall be provided with gravity-doors, which, when closed, shall overlap the window opening at least one inch on all sides; said doors to be held open normally by use of a fine combustible cord in series with a fusible link, so arranged that the doors may easily be released by hand.

Main Door: Outside of door to be provided with a substantial spring, sufficient to keep door closed. Door to be provided with stop to prevent it from swinging into booth or injuring the hinges.

Shelves: To be made up of slate slabs or board not less than seven-eighth inch thick, not exceeding four feet in length or twelve inches in width. Said shelves, if of board, to be painted with at least three coats of asbestos paint, and supported by means of angle-iron. Upper shelf to be used for the rewinding and the repairing of films; the lower shelf to be used for the storage of films. A separate metal case, made without solder, shall be provided for each film when the same is not in the magazine or in the process of winding; said films to be kept in these cases.

Ventilation: Booths to be provided with an inlet in each of four sides; said inlets to be fifteen inches long, three inches high, the lower side of the same not to be more than three inches above floor level. Said inlets to be covered on the inside by a wire of not greater than one-eighth

inch mesh netting, to be firmly secured to the asbestos boards by means of iron strips and screws.

Near the center at the top of the booth shall be a circular opening of not less than ten inches in diameter; the upper side of said opening to be provided with an iron flange; which flange is to be securely fastened to the tee-irons supporting the roof. Securely fastened to this flange shall be a vent-pipe of not less than ten inches in diameter; said pipe leading to the outside of the building or to a special incombustible vent-flue. In this vent-pipe shall be placed a box containing a twelve-inch electric fan; said box to be provided with a door of sufficient size to permit of the examination or removal of this fan; this door to be made tight, and provided with proper fastenings. Box and vent-pipes to be made of galvanized iron or other non-combustible material; far to be so connected that it can be controlled from within the booth.

Wiring: If house lights are controlled from within the booth, an additional emergency control must be provided near the main exit and kept at all times in good condition.

All electric wires to be brought in to the booth and carried to all machines, lights, et cetera, in conduits; one light will be allowed for each machine, and one for the rewinding-bench, but all such lights shall be provided with wire guards.

Rheostats: All rheostats to be mounted on slate insulator, properly supported; said supports to be made of iron and securely fastened to the floor; rheostats to be securely fastened to slate insulator.

Machine: Must be securely fastened to the floor to prevent accidental overturning of the same: Provided, that this section shall not apply to cities of the first and second classes.

Sect. 2. That it shall be unlawful for any person, firm, association, or corporation to erect, set up, construct, maintain, or use any portable booth or enclosure, for the purpose of operating therein moving-picture machines, unless they are built, erected and constructed as follows:

Size: Portable booths or enclosures are to be at least six and one-half feet high and five feet square, and are permitted for the use of one picture machine only.

Frame: The frame is to be made of standard pipe angle-iron, ventilator trap, and suitable fittings. The pipe frame and angle-iron trap are to conform strictly to specifications hereinafter set forth, and the fittings and details of construction must be approved by the Department of Factory Inspection of the Commonwealth of Pennsylvania.

Skeleton Frame: Four corner uprights, to be made of three-quarter inch standard pipe.

Eight horizontal members, to be made of three-quarter inch standard pipe.

Eight corner fittings, to be made of iron or bronze castings.

Ventilator Trap: Ventilator trap to be made of one-inch by one-eighth inch angle-iron, shall extend full width of the top and two inches beyond the front of the top pipe; shall be suitably hinged, not less than two feet from the edge of the front angle corners, and joints to be made with one-eighth inch steel plates, riveted or bolted to each angle-iron by the use of at least two three-sixteenths inch rivets or bolts.

Covering of Booth: The side and top covering of the booth shall be made of an approved pure asbestos cloth, same as used for asbestos curtains, weighing not less than two pounds to the square yard. Seams and hems in the asbestos cloth shall lap at least one inch, and be stitched on each edge with asbestos sewing twine. The top covering shall be made separate from the side covering. It shall completely cover the top and have the outside flap hang down all around the sides, not less than six inches deep. It shall be fastened tightly and secured to the top pipes and ventilator trap by means of asbestos cords. The side covering shall be made in one piece, extending around all four sides, and overlapping at the rear of the booth not less than eighteen inches, so as to form a flap doorway. The side covering shall extend from top pipes—to which it shall be suspended by approved metal hooks or rings, spaced not more than twelve inches apart—to the floor, with a flap of not less than three inches all around resting on the floor. The metal hooks or rings for suspending the side covering shall be attached to the hem of the cloth by means of a metal strap and two rivets. The side covering shall be drawn down tight and secured to the bottom pipe frame by means of asbestos tie cord. The cloth covering for top and sides must at all times be kept free from rents or holes and be maintained in good condition.

The side covering shall overlap eighteen inches in the rear of the booth. This overlap shall extend from top to bottom and shall be so arranged as to form a means of entrance and egress.

Flooring: The frame shall be placed on a mat or carpet made of approved asbestos cloth, not less than seven feet square. This mat must be spread out smoothly on a sub-

stantial floor or platform, so that it shall extend one foot from the frame on all sides.

Ventilation: The top of the frame shall be fitted at the rear with a hinged ventilator trap, as described in foregoing section of frame. The asbestos cloth top covering shall be so arranged and so attached to the frame that, when the hinged trap is raised, the asbestos covering shall be raised also in the rear.

Windows: The look-out window for the operator shall be not more than four inches wide and twelve inches high. The windows for the machine shall not be more than six inches high and twelve inches long. All windows shall be located and cut after machine is set up.

The openings shall be cut in the cloth with care and the edges reinforced by stitched hems of asbestos cloth; they shall be provided with asbestos flaps, securely stitched at the top of the openings. These flaps, when closed, shall overlap the window opening at least two inches on the bottom and sides, and shall be weighted across the bottom edge by a piece of three-eighth inch pipe, or equal weight of metal, securely sewed in the pocket in the cloth.

Window Shutters and Ventilator Trap: The window flaps or shutters are to be held open normally by the use of a fine cumbustible cord. The hinged ventilator trap is to be raised, for ventilation, not more than six inches at the rear, and shall be held open by a collapsible prop sustained by fine combustible cord. The cord from the window shutters and the ventilator prop shall be in series with a fusible link, and also approved tension clip, so arranged that the automatic opening of the link, or release of the tension clip by the operator, will insure the immediate closing of all openings by the dropping of the flaps and the ventilator trap. This fusible link and tension clip shall be arranged in a position directly over the machine, within reach of the operator.

Provided, however, that portable booths or enclosures shall not be permitted to be used in any theatre or public hall in which permanent booths or enclosures have been installed; it being the intention of this section that portable booths or enclosures shall be used only for temporary exhibitions of moving pictures in places of assemblage—such as schools, churches, association halls, lodge rooms, theatres—without permanent booths. Provided, That this section shall not apply to cities of the first and second classes.

Sect. 3. It shall be the duty of the Department of Factory Inspection, by and through its Chief Factory Inspector, his deputy or deputies, to take such means as it

may deem necessary to enforce the provisions of this statute. It shall be the duty of said Chief Factory Inspector, his deputy or deputies, within a reasonable time after the approval of this act, to inspect all booths or enclosures in which moving pictures are now being operated. Any such person or persons, who shall fail to comply with the said order of abatement or discontinuance, so issued as aforesaid, shall be deemed guilty of a misdemeanor, and, on conviction, shall be punished by a fine of not less than twenty-five dollars and not more than five hundred dollars, or an imprisonment in the county jail for a term of not less than ten days nor more than ninety days, within the discretion of the court, for each and every such violation.

Sect. 4 . Any person or persons who violate or ignore any of the provisions of sections one and two of this act shall be deemed guilty of misdemeanor, and on conviction thereof shall be punished by a fine of not less than fifty dollars and not more than five hundred dollars, or an imprisonment in the county jail for a term of not less than ten days nor more than ninety days, for each and every violation.

Laws 1909; No. 206; page 346.

Laws 1911; page 64.

§ 1. That it shall be unlawful for any person or persons to give or participate in, or for the owner or owners of any building, tent, tents, or any premises, lot, park, or common or anyone having control thereof to permit within said building, tent or tents, or any premises, lot, park or common, the exhibition of any fixed or moving pictures of a lascivious, sacrilegious, obscene, indecent, or of an immoral nature and character or such as might tend to corrupt morals.

§ 2. Any person who shall violate any of the provisions of the 1st section of this act shall be deemed guilty of misdemeanor and upon conviction thereof shall be sentenced to pay a fine not exceeding $1,000 or suffer an imprisonment in the jail of the proper county for a period not exceeding one year, or either or both, within the discretion of the court.

Laws 1911; page 746.

To regulate the construction, maintenance and inspection of buildings used for the exhibition of moving pictures in all cities of the first class.

Laws 1913; No. 229.

§ 4 (on page 230). The annual license fee for any places of amusement, buildings, tents or inclosures, or any part thereof situated in any city, borough or township of this commonwealth, which is used for the exhibition of fixed or moving pictures or stereopticon views exclusively (whether scenery or apparatus are employed or not) shall be $25, irrespective of the number of chairs or seating capacity of such places of amusement, buildings, tents or inclosures. (State Board of Censors.)

Laws 1915; No. 239.

§ 2. It shall be unlawful to sell, lease, lend, exhibit or use any motion picture film, reel or view, in Pennsylvania, unless the said film, reel or view has been submitted by the exchange, owner, or lessee of the film, reel or view, and duly approved by the Pennsylvania State Board of Censors.

§ 7. Upon each film, reel or view which has been approved by the board, there shall be furnished and stamped by the board the following certificate or statement: Approved by Pennsylvania State Board of Censors; and shall also furnish a certificate in writing to the same effect, which certificate shall be exhibited to any member of the board or employee thereof upon demand of the holder thereof.

In the case of motion pictures, shall be shown on the screen to the extent of approximately 4 feet of film.

In case of slides or views, each set shall have at least two slides or views shown with a similar statement.

§ 17. For the examination of each film, reel or set of views of 1200 linear feet or less the board shall receive in advance a fee of $1 and $1 for each duplicate or print thereof which must be applied for at the same time and by the same person.

§ 20. Any member or employee of the board may enter any place where films, reels or views are exhibited; and such member or employee is hereby empowered and authorized to prevent the display or exhibition of any film, reel or view which has not been duly approved by the board.

§ 24. Every person intending to sell, lease, exhibit, or use any film, reel or view in Pennsylvania shall furnish the board when the application for approval is made, a description of the film, reel or view, to be exhibited, sold or leased, and the purposes thereof, and shall submit the film, reel or view to the board for examination; and shall also

furnish a statement or affidavit that the duplicate film, reel or view is an exact copy of the original film, reel or view, as submitted for examination to the board and that all eliminations, changes or rejections, made or required by the board in the original film, reel or view has been or will be made in the duplicate.

§ 25. It shall be unlawful for any person to hinder or interfere in any manner with any member or employee of the board while performing any duties in carrying out the intent or provisions of this act.

§ 26. If any elimination or disapproval of a film, reel or view is ordered by the board, the person submitting such film, reel or view for examination will receive immediate notice of such elimination or disapproval, and, if appealed from, such film, reel or view will be promptly re-examined, in the presence of such person, by two or more members of the board and the same finally approved or disapproved promptly after such re-examination, with the right of appeal from the decision of the board to the Court of Common Pleas of the proper county.

§ 27. Any person who violates any of the provisions of this act and is convicted thereof summarily before any alderman, magistrate or justice of the peace, shall be sentenced to pay a fine of not less than $20 nor more than $50 for the first offense. For any subsequent offense the fine shall not be less than $50 nor more than $100. In default of payment of a fine and costs, the defendant shall be sentenced to imprisonment, in the prison of the county where such offense was committed, for not less than 10 days and not more than 30 days.

§ 28. If any person shall fail to display or exhibit on the screen the approval seal as issued by the board of a film, reel or view which has been approved and is convicted summarily before any alderman, magistrate or justice of the peace, he shall be sentenced to pay a fine of not less than $5 and not more than $10; in default of payment of a fine and costs, the defendant shall be sentenced to imprisonment in the prison of the county where such offense was committeed for not less than two days and not more than five days.

COPY OF THE RULES

ISSUED BY THE DEPARTMENT OF WATER SUPPLY, GAS AND ELECTRICITY, NEW YORK CITY

The Operator's License and copy of these rules shall be displayed in a conspicuous place in the booth while the public is in or has access to the premises.

No operator shall conduct an exhibition except where to his knowledge a permit or license of the department of licenses is exhibited on the premises.

The apparatus and its construction shall be tested by the operator prior to each performance. No defective apparatus, or apparatus of a type not approved by this department shall be operated. No apparatus with a lamp served with oxy-hydrogen or acetylene gas shall be approved.

It is forbidden to overfuse (see electrical code, section 418 of the Code of Ordinances) or to make any electrical connections not sanctioned by the aforesaid chapter (see section 438).

The operator shall report promptly every defect in the apparatus or its connection, the correction of which he is unable to secure.

Badly torn films shall not be used and their presence in the booth shall be reported as soon as practical.

The booth at all times shall be kept clean. No pieces of film or loose combustible material shall be allowed to remain in the booth, unless kept in a metal box provided with a close fitting cover constructed without the use of solder.

The door of the booth shall be kept closed while the public has access to the premises.

No person shall be allowed in the booth except the manager or owner of the premises, a licensed operator, a person specially authorized by the commissioner in writing, or any duly accredited officer of the city.

The interior of the booth shall remain readily accessible to the persons mentioned in the foregoing section. The door of the booth shall not be latched on the inside nor the handle removed from the outside, nor shall any signalling device be permitted which is operated from the front of the house.

No film other than that on the machine or on the rewinder shall be exposed in the booth at any time.

No smoking is permitted in the booth at any time.

No matches, fire or open light is permitted in the booth while the public is on or has access to the house or premises.

Every fire, together with the apparent cause thereof, shall be promptly reported.

Advance report shall be made of the installation of a moving picture machine for a one night exhibition.

The apparatus shall at all times be in charge of a licensed operator.

It is forbidden to operate while under the influence of liquor or drug or to read while operating.

Certificates shall not be loaned or transferred.

REGULATIONS GOVERNING THE TRANSPORTATION OF INFLAMMABLE MOTION PICTURE FILMS

Section 246 of Article 20 of Chapter 10 of the Code of Ordinances:

"No person shall transport inflammable motion picture films in any underground subway train, or carry the same into any underground subway station, provided, however, that the provisions of this paragraph shall not apply to inflammable films transported in the course of interstate commerce in railway baggage or express cars under the jurisdiction and subject to the regulations of the interstate commerce commission. No person shall transport inflammable motion picture films in any street car, elevated train, omnibus, ferryboat or other public conveyance, or carry the same into any railway station or ferryhouse unless each film shall be separately enclosed in a tightly closed metal box. Not more than 8 films so enclosed shall be carried at one time by any person."

Adopted by the Board of Aldermen, June 8, 1915, and Effective June 22, 1915.

QUESTIONS AND ANSWERS

Ques. What is a gramme?

Ans. Unit of weight, the weight of a cubic centimeter of water at a temperature of 4 degrees centigrade.

Ques. What is a centimeter?

Ans. The unit of length, one thousandth millionth part of a quadrant of the earth's surface.

Ques. What is a coulomb?

Ans. Unit of quantity—quantity of current which, impelled by one volt would pass through one ohm in one second.

Ques. What is a joule?

Ans. The unit of work, the work done by one watt in one second.

Ques. What is a circular mil?

Ans. A unit of area, a mil is one thousandth part of an inch, and a circular mil is the area of a circle whose diameter is one mil.

Ques. What is ohms law?

Ans. The current in amperes is equal to the electric motive force in volts, divided by the resistance in ohms.

EXAMPLE. If we had 100 volts and 4 ohms resistance in our circuit we would get the amperage (current) by dividing 100 (volts) by 4 (ohms) which would equal 25 amperes.

The resistance in ohms is equal to the electric motive force in volts, divided by the current in amperes.

EXAMPLE. If we had 100 volts and 25 amperes then by dividing 100 (volts) by 25 (amperes) we would get 4 (ohms).

The electric motive force is equal to the current in amperes multiplied by the resistance in ohms.

EXAMPLE. If we had 25 amperes and 4 ohms resistance and we multiplied them we would get 100 (volts).

Ques. How would you judge what size fuse you would use on your line?

Ans. Take into consideration the size of the wire and the amperage to be drawn, the fuse must be the weakest part of the circuit.

Ques. What is meant by conductor? What is generally used for this purpose?

Ans. Anything that allows the passage of electricity through it. Copper.

Ques. What is the carrying capacity of a No. 6 rubber covered wire?

Ans. 50 amperes.

Ques. What is the carrying capacity of a No. 6 weatherproof wire?

Ans. 65 amperes.

Ques. Name the three kinds of wire used in moving picture work.

Ans. Rubber covered wire for mains, asbestos covered wire for lamp leads used between the table switch and the arc lamp (wherever heat is generated) and stage cable used for one night stands.

Ques. State if rubber covered wire, weatherproof wire and asbestos wire are all fireproof?

Ans. No, weatherproof wire is moisture proof but not fireproof.

Ques. What size wire would you use for your mains for moving picture work?

Ans. Size 6 or larger.

Ques. What size wire would you use for your motor connections and what size fuse?

Ans. Size 14 wire and a 6 ampere fuse.

Ques. What is the carrying capacity of a 14 wire?

Ans. 15 amperes.

Ques. On direct current which wire would you connect to the top carbon?

Ans. The positive.

Ques. On which line, your positive or negative, would you connect your rheostat?

Ans. On either line, it makes no difference.

Ques. On which line would you connect a transformer?

Ans. A transformer must be connected to both lines of a circuit.

Ques. What is asbestos covered wire?

Ans. A cable containing very fine strands of copper wires all twisted together and the whole thing covered with asbestos.

Ques. What is rubber covered wire?

Ans. A cable either solid or stranded covered with a rubber covering and an outer protective covering of cotton braid.

Ques. What is stage cable?

Ans. A cable containing twin conductors each insulated from the other and wrapped with a composition covering.

Ques. How would you connect a lug to one of the lamp leads?

Ans. After scraping off the asbestos insulation would insert cable into hole of lug and would tighten up with pliers.

Ques. What is a short circuit?

Ans. Two wires of opposite polarity coming in contact with each other without any controlling device.

Ques. What is a rheostat and how is it constructed?

Ans. An instrument used on your line to produce resistance and bring the current to a fixed working standard.

It is made of a number of metal coils or plates (generally iron or German silver) connected in series and mounted on some insulated material, the whole thing being enclosed in a metal cabinet.

Rheostats are made both adjustable and non-adjustable.

Ques. Can you use rheostats on A. C. or D. C.?

Ans. Rheostats can be used on both A. C. and D. C., but it is cheaper to use an economizer or a transformer instead of a rheostat on A. C.

Ques. How many rheostats would you use on 110 volts?

Ans. One 110 volt rheostat in series on your line.

Ques. If automatic shutter on Powers machine refused to raise when machine started what would you do?

Ans. Put a little oil in oil hole in top of movement; if it still refused to raise, would take off casing and see if shoes or springs were caught or dirty.

Ques. Suppose the automatic shutter raised

up when machine started, but would not stay up, what would you do?

Ans. Put a little heavy oil in movement.

Ques. Suppose the automatic shutter did not drop when machine stopped, how would you fix it?

Ans. Put a little thin oil in movement, and if this failed examine shoes and springs.

Ques. What controls the size of the picture on the screen?

Ans. The focal length of the lens and the distance of machine from screen.

Ques. What would cause a travel ghost on screen?

Ans. The flicker shutter not being adjusted right.

Ques. What would happen if the take-up belt refused to drive take-up or fell off while the machine was running?

Ans. Film would bunch up around lower sprocket and then fall on floor.

Ques. Name six revolving parts on the head of machine, leaving out the sprockets and idlers?

Ans. Flicker shutter, balance wheel, intermittent movement, centrifugal movement, take-up and gears.

Ques. Name the fire prevention devices on the head of machine.

Ans. Upper and lower magazines, upper and lower fire traps, upper and lower fire shields, automatic shutter, cooling plate.

Ques. In threading machine how would you put in film?

Ans. Upside down and the emulsion side towards lamphouse.

Ques. What comprises the optical system in a moving picture circuit?

Ans. The source of light, condensers and lens.

Ques. Name some of the various kinds of lenses.

Ans. Double convex, double concave, plano convex, plano concave, concavo-convex.

Ques. What is meant by the back focal length of lens?

Ans. The distance from the back of the lens to the film in gate while the picture is in focus on screen.

Ques. Of what use are the condensers?

Ans. To bring the light of arc lamp to a point of focus on aperture in gate.

Ques. Which end of the lens goes towards the screen?

Ans. The greatest convex side.

Ques. What is meant by a keystone effect?

Ans. When the machine is set up above the level of the screen and it is necessary to tilt the machine, the bottom of the picture will be wider than the top, owing to the light rays having to travel further to the bottom of the screen than to the top.

Ques. Give your definition of motion pictures.

Ans. An optical illusion based on the persistence of vision.

Ques. What is a fuse, and how many kinds are there?

Ans. A fuse is a safety device used on your

line to protect your circuit. Plug fuses, cartridge fuses and link fuses.

Ques. How many sets of fuses do you use on your line for motion picture work and what would you call them?

Ans. Two, main and booth fuses.

Ques. What size fuse would you use at the main and what size at booth, using No. 6 wire?

Ans. Fifty ampere cartridge fuse at main and 45 ampere link fuse in booth.

Ques. Why not use a 45 ampere cartridge fuse in booth?

Ans. The department calls for the use of link fuses only; the reason cartridge fuses cannot be used in booth is that cartridge fuses are easily tampered with or boosted.

Ques. Why do you use a smaller size fuse in the booth than you do on your mains?

Ans. So that in case of trouble the fuse in the booth will go first (it being the weakest part of the circuit) and you will not have to run down to main fuses in cellar, as you would have to do if main fuses were to blow.

Ques. How would you install a link fuse?

Ans. On a slate base in a metal cabinet fitted with a self-closing door.

Ques. What would happen on your line if you got a short circuit?

Ans. Blow your fuses.

Ques. Can you use a 60 ampere cartridge fuse on your mains on a No. 6 wire?

Ans. No, as this would be overfusing, the carrying capacity of a No. 6 wire is 50 amperes,

and the fuses must be the weakest part of your circuit.

Ques. What is an ampere, a volt and an ohm?

Ans. The ampere is the unit of current, the volt is the unit of electric motive force (or pressure), and the ohm is the unit of electrical resistance.

Ques. What is a watt?

Ans. The electrical unit of power. Amperes times volts equals watts.

Ques. What is a kilowatt?

Ans. 1,000 watts equal one kilowatt.

Ques. How many watts in one horse power?

Ans. 746 watts equal one horse power.

Ques. What is an ampere-hour?

Ans. Current in amperes multiplied by time in hours.

Ques. What is a second?

Ans. The unit of time, the time of one swing of a pendulum making 86,400 swings in a solar day.

Ques. What is meant by the safe carrying capacity of wires?

Ans. All wires will heat when a current of electricity passes through them. The greater the current or the smaller the wire, the greater will be the heating effect. Large wires are heated comparatively more than small wires because the latter have a relatively greater radiating surface.

Ques. What parts of a dynamo are liable to be short circuited?

Ans. The terminals, brush holders, commutator, armature coils and field coils.

Ques. Suppose on looking over your motor you found that there were several ridges on the commutator, where would you look for the cause?

Ans. The brushes are not set right or the tension of brushes on commutator is too great.

Ques. How would you go about setting a Simplex flicker shutter?

Ans. When setting the shutter, set the framing lever in center, move the shutter adjusting block to a point equidistant between the two pins by means of the knob on the back of the mechanism facing towards lamphouse. Four teeth on intermittent sprocket represents one full move of one section on star, moving the sprocket two teeth either backward or forward would mean center. Now adjust shutter as follows: On a three-wing shutter the center of the blade with the word "Simplex" stamped on it should be on center with the lens; on a two-wing shutter the center of either blade will cover the lens. The position can best be determined by the set screw on the spider, which should face the operator in a horizontal position. In setting shutter always keep as close to the lens as possible.

Ques. What is a D. C. to D. C. motor generator?

Ans. It is a D. C. motor connected to a D. C. generator, used to give a D. C. controlled light at arc, thereby doing away with the use of rheostats. When we take into consideration the fact that a rheostat on 110 volt circuit wastes from 35% to 50% of the current, and on 220 volts, rheostats waste from 65% to 75% it will be easily seen why a D. C. generator should be installed in place of rheostats.

Ques. Show by figures what would be the saving if you installed a Hallberg D. C. generator and discarded your rheostats, taking it for granted that you were drawing 80 amperes at the arc on a 110 volt circuit?

Ans. With rheostats we would be consuming 110 volts times 80 amperes or 8,800 watts, while with the generator we would be consuming 110 volts times 57 amperes (this being the amount of current generator draws from line) or 6,270 watts. With rheostats we consume 8,800 watts per hour, while with generator we only consume 6,270 watts per hour, the generator showing a saving of 1,530 watts per hour.

Ques. State what advantage a motor generator has over rheostats aside from the question of current saving.

Ans. You do away with the heat generated by the rheostats.

Ques. What is a Hallberg 4 in 1 automatic regulator?

Ans. Consists of an adjustable transformer with separate line and lamp coils. The primary coil is wound in two sections, each section insulated from the other. Each section is wound for 110 volts. For 110 volts you connect the two sections in multiple while for 220 volts you connect the two sections in series. It is used for moving picture circuits when using the mazda lamp instead of arc.

Ques. What is meant by stealing the arc?

Ans. When two arcs are connected to one source of supply, as when two arcs are connected to one generator, and where the striking of the

second arc automatically puts out or draws from the first arc.

Ques. What is meant by the strength of a current?

Ans. The quantity of electricity which flows past any point of the circuit in one second.

Ques. What is the difference between a dynamo and an alternator?

Ans. A dynamo generates D. C., while an alternator generates A. C.

Ques. Suppose you had one 110 volt 25 ampere rheostat connected on a 110 volt circuit D. C. and you had one 110 volt 25 ampere rheostat connected on a 110 volt circuit A. C. at which arc would you draw the most amperage and why?

Ans. On the A. C. arc because with A. C. you have to feed the carbons closer together than on D. C. and that draws a little more amperage.

Ques. How does a dynamo create current?

Ans. It does not create current but generates an induced E. M. F. which causes a current to flow through a circuit.

Ques. How should a knife switch be installed?

Ans. So that gravity tends to open same.

Ques. Is it possible to reverse the rotation of a motor, if so, how?

Ans. Yes, by reversing the current through the fields or the current through the armature.

Ques. What is the difference between a D. C. and an A. C. rheostat?

Ans. Rheostats are made for either A. C. or D. C. There is no difference between them.

Ques. How many rheostats would you use on 220 volts and how would you connect same?

Ans. One 220 volt rheostat in series with your line or two 110 volt rheostats in series with each other and in series on your line.

Ques. With 55 volts coming in, how many rheostats would you use, and how would you connect same?

Ans. Use two 110 volt rheostats in multiple with each other and in series on your line.

Ques. What effect does it have by connecting rheostats in multiple and rheostats in series?

Ans. Rheostats in series give you the sum of their resistance, for instance if they each offered 4 ohms resistance and we connected same in series with each other we would have 8 ohms resistance on our line. If we connected the same two rheostats in multiple we would only then have approximately 2 ohms resistance.

Ques. Why don't they use copper coils instead of iron in a rheostat?

Ans. Because iron offers more resistance than copper, copper being a good conductor.

Ques. Is all the resistance offered in your rheostat?

Ans. No, everything on your line offers resistance, all substance offers resistance to the passage of electricity through them, the amount of resistance depending on the substance and its size, that is, on its length and cross section.

Ques. Do metals offer more or less resistance when hot?

Ans. The resistance of all metals increases with an increase of temperature, while carbons and insulating materials decrease with an increase of temperature.

Ques. Is it possible to get a short circuit in the rheostat?

Ans. Yes, when the arc lamp is burning, as you then have two polarities in rheostat.

Ques. How many kinds of current are there and state what they are.

Ans. Two, direct current and alternating current.

Ques. What is meant by direct current?

Ans. Direct current is a current that always flows in the same direction; always leaves the dynamo through the positive pole and returns through the negative pole.

Ques. What is alternating current?

Ans. Alternating current is a current that changes its flow of direction so many times a second. Each part of the circuit being so many times positive and so many times negative every second.

Ques. What is current frequency?

Ans. The number of times alternating current changes its flow of direction in a second. (These changes are called cycles.)

Ques. Which current is the best for moving picture work and why?

Ans. Direct current gives a better arc, more easily controlled, and is not so noisy as A. C.

Ques. Is it possible to change A. C. into D. C.?

Ans. Yes, there are various machines on the market for this purpose—transverters, arc rectifiers and motor generator sets.

Ques. Suppose you had 110 volts D. C. coming into the theatre and you had one 110 volt rheo-

stat on your line, and then the current was changed from D. C. to A. C. what changes would you make on your line and state reasons why?

Ans. Would take off the rheostat and install an economizer (step-down transformer); this would give me a saving of about 66% (makers claim).

Ques. Suppose you changed a rheostat for an economizer on a 220 volt line, would there be a saving? If so, about how much?

Ans. About 80% (makers claim).

Ques. State an easy way to test whether you have A. C. or D. C. at arc lamp, and if you are on D. C. whether you are connected right (positive line connected to top carbon).

Ans. First strike the arc and let it burn a second or two, then throw off the switch and open lamphouse door, if both carbons remain red for the same length of time we have A. C., but should one carbon remain red longer than the other we have D. C. The top carbon should remain red longest, so if the bottom remains red longer than the top we know that we are burning upside down. (Positive line is connected to bottom carbon instead of to top).

Ques. Suppose you find you are burning upside down, where on your line would you make the change?

Ans. At table switch, arc lamp or wall switch.

Ques. Could you change polarity at the rheostat if you were burning upside down?

Ans. No, as you have only one polarity at the rheostat.

Ques. What is meant by constant current type of a current rectifying device?

Ans. Where two arc lamps are connected to one apparatus like a transverter or a motor generator, and where the voltage and not the amperage is doubled when both arcs are struck. For instance, if we had one arc operating at 55 volts and 50 amperes and we struck the second arc we should then have two arcs operating at 50 amperes 110 volts ((approximately).

Ques. What is a three wire system?

Ans. A distribution system invented by Edison, where two dynamos are connected in series and the third or neutral wire is taken from a point common to both dynamos.

Ques. How many rheostats would you use if you were using the two outside wires of a three wire system?

Ans. Two 110 volt rheostats in series with each other, as between the outside wires we would have 220 volts.

Ques. Suppose you were drawing 50 amperes off one side of a three wire system and 40 amperes off the other, how many amperes would be flowing in the neutral wire?

Ans. As the amount of current in the neutral wire is the difference between the amperage drawn off either side, we would have a flow of 10 amperes in the neutral wire.

Ques. Suppose that we were drawing 45 amperes off either side of a three wire system what would be the amount of amperage flowing in the neutral wire?

Ans. If we were drawing 45 amperes off each side of the system, the system would be balanced

and there would be no flow of current in the neutral wire.

Ques. What are the advantages of a three wire system?

Ans. The saving of copper is the advantage of the system, as by its use the size of the conductors may be reduced, by increasing the pressure at which the current is transmitted, without increasing the voltage of the lamps. If, for example, the neutral wire is made the same size as the two outside wires, the total weight of the copper for the three wire system will be three-eighths ($3/8$) of that required for two two-wire systems for the same load, distance and percentage of loss.

Ques. What are the disadvantages of a three-wire system?

Ans. The system is more complicated, the cost of the switches, panel boards, etc., is increased, that the system is more subject to disturbances, if for example the fuse on the neutral wire should melt, the lamps on the system might be considerably damaged in case the two sides of the system were not balanced.

Ques. Can you connect between the positive and neutral wire for moving picture work?

Ans. Yes, you will then need one 110 volt rheostat.

Ques. Which wire on a three-wire system is grounded?

Ans. The neutral wire.

Ques. If we were connected on the positive and neutral wires of a three-wire system, and we got a ground on the lower jaw of arc lamp, would that blow the fuse.

Ans. No, all metal machines must be grounded, and by so doing the lamphouse becomes the same polarity as the neutral wire. Therefore the ground being on lower jaw which is neutral and the same polarity as lamphouse, it may not blow the fuse.

Ques. What is a transformer, how is it made and how does it work?

Ans. A transformer consists of two copper coils, the primary and the secondary, and a laminated iron core. The two coils are insulated from one another and from the core. The primary coil is connected to the source of supply and the secondary is connected to the lamp. As a matter of fact these coils are each usually made of several sections. The voltage induced in the secondary coil is equal to the voltage impressed on the primary coil multiplied by the ratio of the number of turns in the secondary to the number in the primary coil, less a certain drop due to impedance of the coils and to magnetic leakage. This drop is negligible on no load. Step-up transformers are used to raise the voltage. Step-down transformers are used to step down the voltage. The efficiencies of transformers are high, varying from 94% to 95% at one-fourth load to 98% at full load for sizes above 25 K. W.

The current enters the transformer through the primary coil and the alternations of the current in this coil sets up a magnetic field in the transformer. The secondary cuts the lines of magnetic force and carries off a new current to the arc lamp.

Ques. Does a transformer change the current from A. C. to D. C.?

Ans. No, it gives off a magnetized A. C. current to arc lamp.

Ques. Can you use a transformer on direct current?

Ans. No.

Ques. Why do they make the core of a transformer of a soft metal like iron, instead of steel?

Ans. Because the softer the metal the more easily it is to magnetize and it will lose its magnetism quicker after the current has been shut off.

Ques. State in one word how an economizer or transformer works?

Ans. Induction .

Ques. What is meant by induction?

Ans. A charged body running parallel to another body (it being a conductor) tends to charge the neighboring body without any tangible form of connection.

Ques. How are the coils in a transformer or economizer connected, in multiple or series?

Ans. They are *not* connected, they are insulated from each other.

Ques. What is the difference between an economizer, an inductor and a step-down transformer?

Ans. None, they are all the same and answer the same purpose.

Ques. Where on your line would you connect your economizer and why?

Ans. Between the table switch and the arc lamp, so that by pulling the table switch you put the arc and the economizer out of commission at the same time, whereas if economizer was connected between the table switch and the wall switch it would be necessary to pull both switches

or at least pull wall switch to put both out of commission.

Ques. How many working parts are there in a transformer?

Ans. None.

Ques. Where is the difference between a step-up and a step-down transformer?

Ans. In the ratio of the coil windings.

Ques. What is a transverter?

Ans. A motor generator set, an A. C. motor connected to a D. C. generator gives a D. C. current at arc lamp. Or a D. C. motor connected to a D. C. generator that gives a controlled D. C. current at arc lamp.

Ques. What is a mercury arc rectifier used for?

Ans. To change A. C. to D. C.

Ques. What is the difference between a motor, a motor generator and a generator?

Ans. A motor transforms electrical into mechanical power. A generator transforms mechanical power into electrical power. A motor generator is a device consisting of a motor mechanically connected to one or more generators.

Ques. What is the difference between a starting box and a speed regulator?

Ans. Motor starting rheostats or starting boxes are designed to start a motor and bring it gradually from rest to full speed. They are not intended to regulate speed and must not be used for that purpose. Failure to observe this caution will result in burning out the resistance which in a motor starter is sufficient to carry the current for a limited time only, whereas in a speed regu-

lator, sufficient resistance is provided to carry the full load current continuously.

Ques. What is meant by self-induction?

Ans. A characteristic of alternating current circuits, where the current tends to create a counter E. M. F. Self-induction varies greatly with conditions depending upon the arrangement of the circuit, the medium surrounding the circuit, the devices or apparatus supplied or connected in the circuit, etc. For example, if a coil having a resistance of 100 ohms is included in the circuit, a current of one ampere can be passed through the coil with an electric pressure of 100 volts, if direct current is used; while it might require a potential of several hundred volts to pass a current of one ampere if alternating current is used, depending upon the number of turns in the coil, whether it is wound on iron or some other non-magnetic material.

Ques. State six reasons for the film jumping on the screen.

Ans. Dirt on sprockets, especially the intermittent sprocket, losing the bottom loop, not enough tension in gate of machine, sprocket shaft not true, shaft bushings badly worn, holes in the films worn.

Ques. Suppose you blow the fuse when you strike the arc, where would you look for the trouble?

Ans. In the rheostat.

Ques. Suppose you blow the fuse when you close the table switch, where would you look for the trouble?

Ans. Between the table switch and the arc lamp.

Ques. If you strike the arc and only get a spark and carbons refuse to hold arc where would you look for the trouble?

Ans. Loose connection or oxidized connection in rheostat or on line.

Ques. Is it possible to get a fire on the machine, if so, how?

Ans. Yes, bad patches in film opening up while going through machine, torn sprocket holes on each side of film, take-up refusing to work, automatic shutter failing to work, film breaking in gate between upper and intermittent sprocket, dirt and pieces of film gathering in film aperture in gate.

Ques. State what you would use to test for ground or open circuit in rheostat.

Ans. A bell set.

Ques. How would you test for ground and how for open circuit in rheostat?

Ans. First test bell set by connecting both terminals together, if you get a ring then set is all right and proceed as follows: Place one of the terminals of bell set on the frame of rheostat and the other terminal on the first coil or plate of rheostat, if you get a ring, then rheostat is grounded. If you do not get a ring then rheostat is free from ground. If grounded, to locate which plate or coil is causing the ground, proceed as follows: Place terminal of bell set on frame and other terminal on first coil, if you get a ring, disconnect first coil then test the second and so on till bell stops ringing. As soon as bell stops ringing it signifies

that, the coil that you disconnected last is the coil that was grounded.

To test for open circuit, place the terminals of bell set on the terminals on rheostat and if you get a ring then rheostat is O. K.

Ques. If you were drawing 30 amperes on a 110 volt circuit, how many kilowatts would you be using?

Ans. Volts times amperage equals watts so 110 x 30 equals 3,300, and as there are 1000 watts in a kilowatt that means that we have 3 3/10 K. W.

Ques. How would you measure a No. 6 rubber covered stranded wire?

Ans. First, scrape off the insulation, then measure one of the strands with a B. & S. wire gauge, we would find that this strand would be a No. 14, then by referring to the wire table we would find that a 14 wire contains 4,107 circular mils, then we count the strands in the cable and we find there are seven, so we multiply 4,107 by 7 which equals 28,749, then we again refer to wire table to find the nearest number to 28,749 which is 26,250 and looking across wire column we find that this is a No. 6 wire.

Ques. State how you would test lamphouse for grounds.

Ans. Take test lamp and after making sure that there was current in the lamphouse (by placing test lamp terminals on carbons) would proceed as follows: Would place one terminal of test lamp on the upper carbon and the other terminal on lamphouse, if test lamp lights, then the lower jaw must be grounded, if we do not get a light then lower jaw is O. K. Then we place one of the

test lamp terminals on the lower jaw or carbon and the other terminal we place on metal of lamp-house, if we get a light then the upper jaw is grounded, if we do not get a light then the upper jaw is O. K. If machine was grounded we would of course remove ground wire before making the test as above.

Ques. Name three essential parts of a dynamo.

Ans. Armature, commutator, field coils.

Ques. What is the object of the field magnets?

Ans. To provide a field of magnetic lines of force to be cut by the armature inductors as they revolve in the field.

Ques. What is an armature?

Ans. A collection of inductors mounted on a shaft and arranged to rotate in a magnetic field with provision for collecting the current induced in the inductors.

A simple loop or turn of wire may be considered as the simplest form of armature.

Ques. What is a commutator?

Ans. A device for causing the alternating currents generated in the armature to flow in the same direction in the external circuit. It consists of a series of copper bars or segments arranged side by side forming a cylinder and insulated from each other by sheets of mica.

Ques. How do armature and field magnets differ in dynamos and alternators?

Ans. In the dynamo the field magnet is the stationary part and the armature revolves. While in an alternator the reverse is the case.

Ques. Name five parts of a dynamo.

Ans. Bed plate, field magnets, armature, commutator, brushes.

Ques. The primary coil of a transformer is supplied with a current of 25 amperes at 2,000 volts, the pressure received from the secondary is 250 volts. What is the current from the secondary coil, taking it for granted that the transformer is 100% efficient?

Ans. Input equals output. Input is 2,000 times 25 equals 50,000 watts. Watts divided by volts equals amperes, so 50,000 divided by 250 equals 200. Therefore the current from the secondary is 200 amperes.

Ques. What is the name of the coil in which the current is induced?

Ans. The secondary.

Ques. What is the proper rate of speed of showing 1,000 feet of film?

Ans. About fifteen to seventeen minutes. Or about sixteen pictures to the second.

Ques. If the machine is running at proper speed (sixteen pictures to the second) about how long is each picture held on the screen?

Ans. For one-sixteenth part of a second *less the time it takes the intermittent sprocket to move the film.*

Ques. Mention some of the different makes of moving picture machines.

Ans. Powers, Simplex, Standard, Motiograph, Baird, Edison, Lubin, Pathe, Kinemacolor, Cameron.

Ques. Which would show the greater saving, a D. C. economizer or rheostats?

Ans. The initial cost of the D. C. economizer

would be greater than that of rheostats, but the working cost of the D. C. economizer would show a great saving over that of the rheostats.

Ques. Why are flicker shutters made with two or three blades when only the largest blade is used to cut off the picture from screen while the film is in motion in gate of machine?

Ans. The second and third blades are on to equalize the light.

Ques. What is a wire gauge?

Ans. A gauge used to measure wires.

Ques. What is the difference between Greenfield and B. X.?

Ans. Greenfield is a metal tubing without wires while B. X. is the same tubing with wires.

Ques. Does a transformer take any current when the switch on the lamp side of same is open?

Ans. Yes. A no-load passes through the primary.

Ques. What is meant by an oil-cooled transformer?

Ans. A transformer filled with mineral oil to help keep the transformer cool, never used on moving picture work, the fire risk is too great.

Ques. What would cause the breaking of a brand new film while passing through the machine, taking it for granted that the film was handed to you in perfect condition, and that you had just run some six or seven reels of film through the machine without mishap?

Ans. Caused by the emulsion coming off the new film and adhering to the tension bars in gate of machine, which would give undue tension to the film.

Ques. What is meant by fading a picture? When and how is it done?

Ans. Fading is done by the gradual cutting off of the light (either when taking or projecting the picture). The operator fades one reel into the other when changing from one machine to the other. This is accompanied by the dowsers on the machines, by slowly closing one and at the same time slowly opening the other.

Ques. On which coil of an economizer is the greatest wattage?

Ans. As transformers are not 100% efficient there is a loss in transforming the current, this loss amounts to approximately 5% and as the output equals the input less the loss, it will mean that we have more wattage on the primary than on the secondary.

Ques. What is the inverse of resistance?

Ans. Conductivity.

Ques. State one of the disadvantages of using A. C. for motion picture work.

Ans. Both carbons form a crater and the arc keeps traveling around carbons making it difficult to get a good steady light on screen.

Ques. Of what use is the field magnet in a dynamo?

Ans. To provide a field of lines of force to be cut by the armature inductors.

Ques. State one of the advantages of A. C. over D. C. as far as transmission goes.

Ans. Reduces the cost of transmission by using high voltage and transformers.

Ques. What is the armature?

Ans. A collection of inductors mounted on a

shaft and arranged to turn in a magnetic field for collecting the current induced in the inductors.

Ques. What is a commutator?

Ans. A device for causing the alternating currents generated in the armature to flow in the same direction in the external circuit.

Ques. Which end of the lens faces arc?

Ans. The flat or lesser convex end.

Ques. What would you use to scrape off the emulsion from tension bars?

Ans. Copper or any soft metal.

Ques. Where is the most luminous part of an arc?

Ans. In the crater of the positive carbon.

Ques. What is the difference between a D. C. converter and a rotary converter?

Ans. A D. C.. converter converts D. C. to D. C., while the rotary converter converts A. C. to D. C.

Ques. What is meant by a circuit?

Ans. The path in which the current flows.

Ques. What is a closed circuit?

Ans. When all switches, etc., on a line are closed giving the current a continuous path.

Ques. What is meant by insulation?

Ans. Some non-conducting material on or around a conductor to prevent the escape of current.

Ques. Show by sketch how a lens is set and how it works.

Ans. See article on optical projection.

Ques. What is a circuit breaker?

Ans. A switch which opens automatically when

the current or pressure exceeds or falls below a certain fixed standard.

Ques. What effect has it by connecting dynamos in series and dynamos in multiple?

Ans. Dynamos in series increase the volts, dynamos in multiple increase the amperes.

Ques. Name a number of good conductors, fair conductors and non-conductors.

Ans. Silver, copper, mercury and aluminum are good conductors. Water, the body, and dry wood are partial conductors and mica, slate, glass are non-conductors.

Ques. Describe fully what is meant by an electric arc.

Ans. Suppose two carbons are connected in an electric circuit, and the circuit closed by touching the tips of the carbons together (striking your arc) ; on separating these carbons again the circuit will not be broken, providing the space between be not too great, but will be maintained through the arc formed at this point. The current is assumed as passing from the upper carbon (positive) to the lower carbon (negative). We find in a direct current arc that most of the light issues from the tip of the positive carbon, and this portion is called the crater of the arc. The lower carbon becomes pointed as the upper one hollows out to form the crater. The negative carbon is also incandescent, but not to the same extent as the positive. Between the carbons there is a band of violet light (the arc proper) and this is surrounded by a luminous zone of a golden yellow color. The carbons are worn away or consumed by the passage of the current. The posi-

tive carbon being consumed about twice as quick as the lower.

With alternating current the upper carbon becomes positive and negative alternately, and there is no chance for a good crater to be formed, both carbons giving off the same amount of light and being consumed at about the same rate.

Ques. What is a voltmeter used for and how would you connect same?

Ans. Used to measure the pressure or voltage, connected in multiple on your line.

Ques. What is an ammeter and how is it connected?

Ans. Used to measure the current or amperage, connected in series on the line.

Ques. What causes hissing of an electric arc?

Ans. Feeding carbons too close together, feeding it a higher current than that required for the length of arc employed.

Ques. What is the reason of using a cored carbon in the positive jaw of arc?

Ans. To reduce the voltage required to maintain the arc by lowering the boiling point or the vaporizing temperature of the crater.

Ques. State the advantages of rubber as an insulator.

Ans. It is flexible, fairly strong and waterproof.

Ques. Can you use a bell set to find ground in lamphouse?

Ans. Yes. Place one terminal of bell set on upper carbon and other terminal on lamphouse frame, if bell rings then the upper jaw is grounded, if no ring then upper jaw is O. K.

Then place one terminal of bell set on lower carbon and other terminal on lamphouse, if bell rings then the lower jaw is grounded, if you do not get a ring then lower jaw is O. K.

Ques. How often would you test lamphouse for grounds?

Ans. Before show each day.

Ques. Suppose you found that either the upper or lower jaw was grounded, where would you first look for the trouble?

Ans. Probably the mica insulation has worked out of jaws of lamp.

Ques. State what care you would take of film while it is in your charge.

Ans. Would examine all film before showing, keep each reel in a metal box or can, and keep all these cans in another metal box constructed without solder and with a self-closing door.

Ques. Name three causes of sparking at your motor.

Ans. Dirt, uneven brushes and broken segment in the commutator.

Ques. Under what conditions can you rewind film in the booth?

Ans. Never rewind films in booth while arc is burning, or while audience is in theatre.

Ques. What would you do in case of fire in the booth?

Ans. Stop motor and switch off arc, drop the booth shutters, turn on the house lights, notify manager and try and extinguish fire.

Ques. What precautions would you take to prevent fires?

Ans. Keep all films in fireproof cans, only have the film on the way to the machine exposed at any time, keep booth free from all pieces of film and all combustible material, see that take-up and automatic shutter work O. K., keep lamphouse free from all grounds, keep all electrical connections tight, keep machine clean and in good running order, have a bucket of water and one of sand near at hand in booth, place all hot carbons into a bucket of water when you take them from arc lamp.

Ques. How would you adjust the take-up without stopping the machine?

Ans. If the belt was slipping would use a little rosin or tighten up the tension screw, or use the idler pulley if machine was equipped with one. If take-up refused to revolve the bottom reel, would stop machine and fix.

Ques. Why do they ground an all metal machine?

Ans. For safety.

Ques. How would you find the amount of resistance offered by any conductor?

Ans. The resistance of any conductor is equal to its length in feet divided by the area in circular mils multiplied by the resistance per mil-foot (which is 10.5 ohms).

Ques. What is the international ohm?

Ans. The resistance offered by a column of pure mercury 106.3 centimeters in length by one square milimeter in cross section at a temperature of zero centigrade.

Ques. What percentage of light is lost between the arc lamp and the screen?

Ans. Take the crater of arc as 100%, only 33%

of this is picked up by the condensers on D. C. (On A. C. the percentage is much less.) Then there is a 16% reflection loss (4% at each of the four glass-to-air surfaces of condensers) plus an absorption loss of 9% (absorption loss being reckoned as 6% per inch, and assuming the condenser combination to have an axial thickness of 1 1-2 inch) or, in other words, the light falling upon the condensers is subjected to a reduction of 25% in passing through them. Thus only 25.75% passes on to the film being projected. About 50% of this light will be lost passing through the film, so that only 12.85% is sent on to projection lens. In its passage through the objective lens the light is further reduced some 25% in intensity (4% reflection loss at each of the six glass-to-air surfaces) therefore but 9.65% emerges from lens. This is again cut 50% by the flicker shutter, leaving only 4.80% of the original amount emanating from arc lamp for the illumination of the screen picture. Other factors such as the distance to screen and the effective aperture of the objective also enter, so this is only a rough approximation.

Ques. What is a six to one intermittent movement?

Ans. A movement with which each picture on the film is moved into place before the aperture of the projector in an interval of time equal to one-sixth of the period required for a complete revolution of its driving member (cam).

Ques. Is both voltage and amperage used up in arc lamp, or is the voltage used up and amperage returned; or is the voltage returned to dynamo and amperage used up at arc?

Ans. The voltage is used up forcing the amper-

age through the resistance. The amperage returns to dynamo. This can be proved by connecting an ammeter in your circuit.

Ques. What would be the result if you lost your bottom loop?

Ans. Film would jump or break.

Ques. What regulates the speed of the reels in the upper and lower magazines?

Ans. The top reel is regulated by film tension and the lower is regulated by the tension spring and split pulley.

Ques. Of what use is the flicker shutter on head of machine?

Ans. To cut off the rays of light from screen while the film is in motion in gate.

Ques. What causes the film to remain stationary in gate of machine?

Ans. The intermittent movement.

Ques. What is it that works the automatic shutter?

Ans. The centrifugal movement.

PROJECTIONIST'S LIBRARY.

There are many good books on the market from which the studious projectionist can obtain much useful information. However, from past experience it is our belief that the average projectionist is satisfied with one or perhaps two technical books. As the majority of operators place all their eggs in one basket, it is absolutely essential that the basket be a good one.

Some little time ago the "Exhibitors Trade Review," a publication devoted exclusively to the interests of the Motion Picture industry, made an extensive canvass in the industry just to find out which books were used by projectionists, managers, etc. The following is an article from the "Exhibitors Trade Review" stating the result of that canvass:

Reprinted from "Exhibitors Trade Review"

BOOKS PROJECTIONISTS READ

From time to time, this department has received requests from projectionists in different parts of the world, asking us to recommend good books on projection and tell them from whom they could be secured. Rather than take the responsibility of answering this question without consulting others, we ran an article on what projectionists read, not so long ago, and asked our readers to write in telling us what books on projection they considered the best.

It is a well known fact that owing to the peculiarly arranged hours projectionists have to work, it makes it difficult for them to read very much. Not only that, but it is a proven fact that the majority of human nature does not care to read dry technical stuff along the lines of their daily occupation, after they pass a certain length of time

in that business. The number of answers we received from this article, however, leads us to believe that projectionists as a body like to read technical stuff about their daily occupation, as answers came from every part of this country, Canada, a few from England and one or two from far-off Australia. The truth of it is we know it to be a fact now that they do read, and we are in position to answer the queries we have had about what to read.

"Motion Picture Projection" by James R. Cameron led the list 78½ per cent of the total answering stating that was the book they read. "Electrical Guides" (10 volumes) was next with a percentage of 11½. "Handbook on Projection" was read by 5 per cent of the projectionists answering, while 2½ per cent stated they read "Motion Picture Electricity." Only 1¼ per cent stated they had read "Motion Picture Optics" and "Transactions of the Society of Motion Picture Engineers."

This list might be taken now as representative, as it contains the books selected by the projectionists themselves as the ones from which they have derived the most information, and is not the opinion of just one man. It is a good rule to never go by what just one person says about a book, but to abide by what the majority says, and the above list shows what the majority think in this case.

As will be seen by the above figures, the writer's work, "Motion Picture Projection," stands away ahead of every other book on the subject. With a copy of this book, a set of Hawkin's Electrical Guides, a copy of Gage's Optics, and by making use of the Transactions of the Society of Motion Picture Engineers and the projection columns of the Motion Picture News and Exhibitors Trade Review, the progressive projectionist will have at hand sufficient technical information and data to keep him posted up to date.

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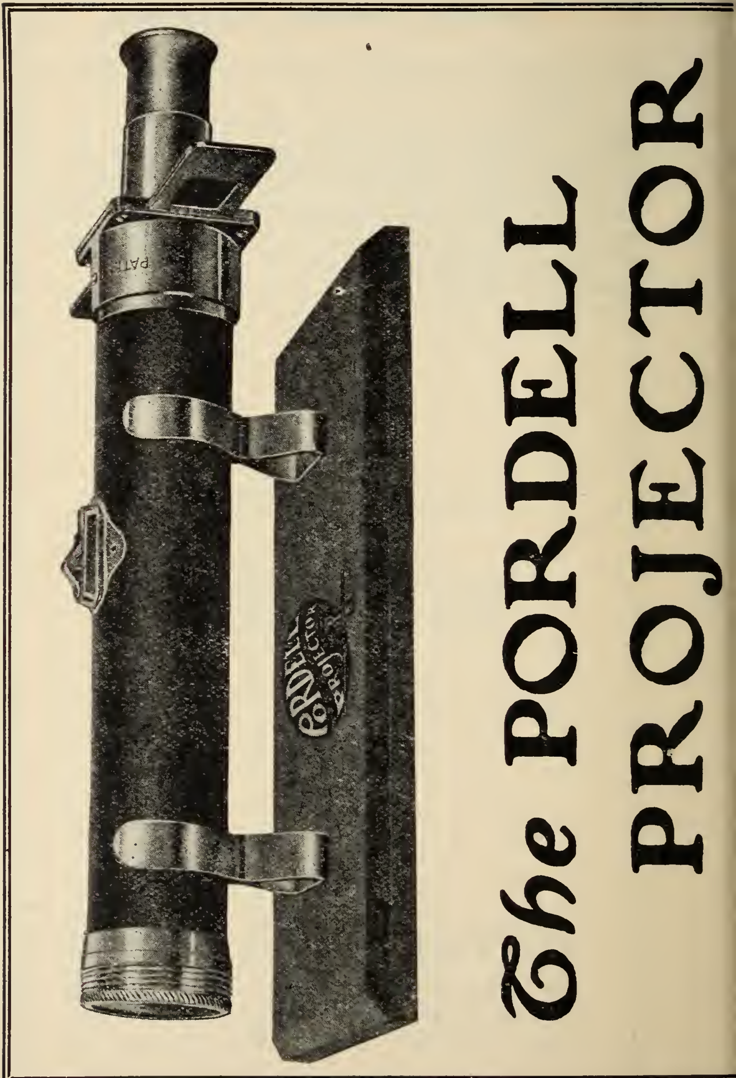
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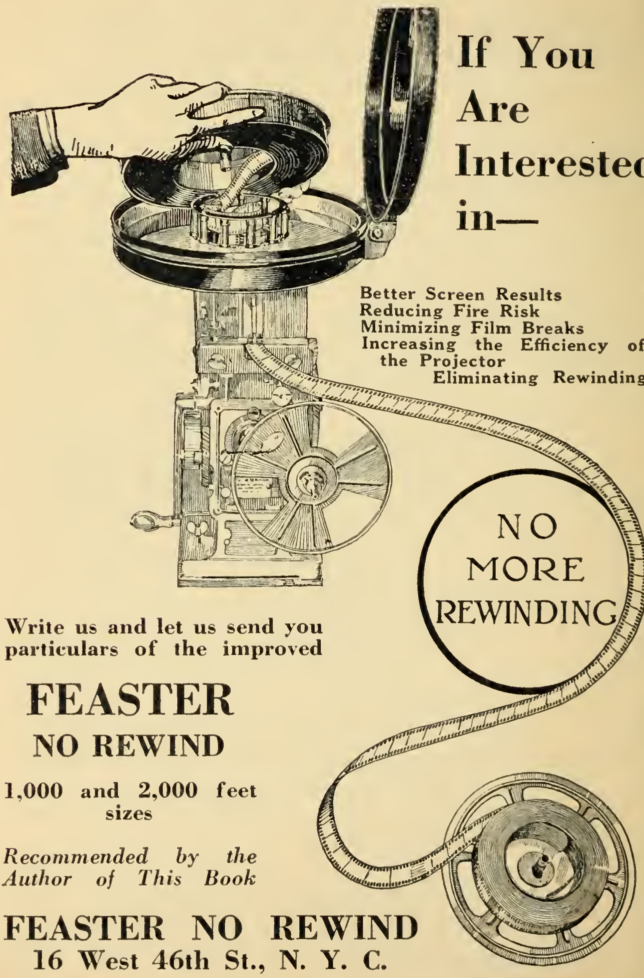

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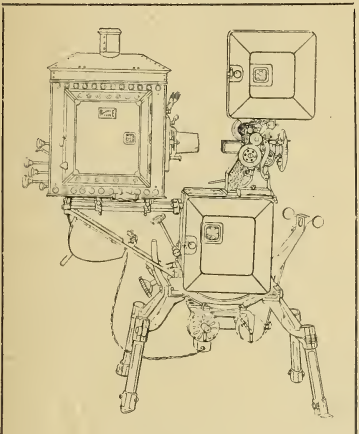

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